AN AMERICAN KEW.

ON the banks of the Thames, about a dozen miles from London in a southerly direction, lies the ancient town of Twickenham. In the seventeenth century, Alexander Pope had a villa there; somewhat later, Horace Walpole built his rococo castle at Strawberry Hill, a mile beyond the village; and close by, to the north, is Whitton, where Sir John Suckling lived. Within an easy hour's walk stands Hampton Court, built by Cardinal Wolsey of haughty and unhappy memory, and approached through the magnificent avenue of Bushey Park. Nearly as far in the opposite direction is Richmond, with its venerable bridge and famous hill, the latter commanding a view of rural English landscape which, as Thackeray says, looks as if it had its hair curled, like the waiters at the inn on its summit. A mile down the river from Richmond, and six miles from London, extend the renowned botanical gardens of Kew.

It will be seen, therefore, that Twickenham was not a bad place for a suburban residence: the roads were excellent, the scenery and associations delightful, and, by taking the train, one could be at Waterloo railway-station, in the heart of London, in half an hour. I lived there several years, and know something about it.

The most agreeable expedition of all, taking one month with another, was to Kew Gardens. In winter, it was a luxury to sit in the hot-houses; in summer, it was lovely throughout. You could travel thither by train; but the best way was to go on foot. Passing through Twickenham town, and through the church-yard, with its gravestones centuries old, you came out upon the river banks. Here a broad, well-kept path followed the enchanting windings of the stream, and skirted the lawns of pretty villas on the left. On the right, soon appeared the green heights of the Hill, with clumps of mighty oaks, and the gleaming ramparts and windows of the hostelry over all. At its foot, on the river, were boat-houses and "hards," with slender rowing-craft drawn up, or lying afloat, or pushing off into the current with their freight of white-jerseyed oarsmen. And now came into view the quaint, hog-backed bridge, with its high stone parapet, and the eddies swirling against its piers; and Richmond itself, red with brick, white with stucco, green with trees; irregular and diversified in outline; resting snug against the base of the Hill, and clambering some distance up its long slope.

You crossed the bridge, lingering on the way to admire the railroad bridge a few hundred yards farther down, reflected in the river-mirror. Between the two bridges are a couple of islets, only a few yards in diameter, but with trees growing on them; and hereabouts are generally moored three or four fishing-punts, in which sit patiently, all day long, stout, middle-aged fishermen, watching their cork floats drift down the stream, and faithfully hoping that each new cast will bring

the long-expected fish. Often have I watched them, but the fish never came. Probably, as Hood conjectured, "it was caught yesterday."

The river-side walk now continues along the Richmond side of the river. For half a mile, it has the town on the right. Then the boundaries of Kew Gardens begin, and here is the most beautiful part of the walk. Immense trees stretch their ponderous boughs far across the path, and they droop so low that the pendent foliage almost sweeps the water. Through the fretted sun and shadow the path winds; every little way there is a hospitable bench, resting on which you gaze forth upon the quiet-moving river, with its passing wherries, its reflections of sky and cloud, and its battlemented residences far withdrawn beyond green meadows on the opposite side. The path is never overcrowded, even on holidays; but you may always see lovers wandering arm in arm along it; and occasionally there is a brisk exchange of "Thames chaff" between the occupants of the skimming boats and the loiterers on the shore. Meanwhile, the great domain of Kew keeps pace with you on the other hand. You are divided from it by a wide water-ditch, backed by a high stone embankment, in turn surmounted by an iron railing. But your eyes may stray whither feet cannot follow; and you note the lovely groves, the beautiful green glades and gracious vistas, the secluded paths weaving in and out, and now and then you catch the sparkle of lofty domes of glass rising above the trees, looking for all the world like gigantic soap-bubbles. It is a sort of fairy-land beyond there; and long before you arrive at the entrance your appetite for what lies within is sharp-set.

The feast in store for you more than fulfils expectation; but at this point, since we are journeying in imagination only, and miles count for nothing, we will turn back, and enter the gardens from the other end. By this route we approach its beauties gradually and in due order, and our pleasure has opportunity to grow from promising beginnings to complete content. The gate is small here, and the uniformed guardian simply gives us a glance, to assure himself that we are not toughs or pickpockets. Kew Gardens are free to the public in the afternoons, barring only the rowdy element. The public would like to have them free in the mornings, too; and, for aught I know, Sir Joseph Hooker may have yielded his assent by this time. But in the seventies, when I was there, he resisted on the ground that it was necessary to close the gardens for half the day, in order to allow time for study, and for keeping the houses and plantations in order. The grounds are constantly visited by gardeners and botanists from all parts of the country, and from the world at large; and these persons require some measure of seclusion in order to prosecute their labors and investigations. Practical botany is not, as a rule, pursued at night; though, with the aid of electric lights, no doubt it might be.

However, we have by this time passed through some introductory shrubbery, and have emerged into a straight, open avenue, a third of a mile or more in length. Directly before us is an immensely high tower,—I should think nearly two hundred feet,—painted red, black, blue, and yellow, and fashioned to resemble a Chinese minaret or pagoda. The central shaft is circular, and, I believe, of masonry; but it is sur-

rounded at short intervals by wooden balconies, and the roof is of a concave conical shape, like a mandarin's hat. I never saw any signs of life in this tower, and do not know what it is used for; but I have heard that the son-in-law of Lord Capel (who first laid out Kew Gardens some two hundred years ago) added to the importance of the place by making it the head-quarters of English astronomy; and this tower, which certainly would make an excellent observatory, may have had something to do with that.

Beyond the tower extends a broad, straight path, between well-kept lawns, on which are planted trees of both native and foreign growth. Towards the river, on the left, the grounds are irregular and diversified with clumps of trees, ponds, and grassy undulations. On the right, concealed by a hedge of foliage, is the highway between Richmond and London. Before us, at the end of the walk, is an iron fence, dividing the inner enclosure—the Botanical Gardens proper—from this outer region. We reach it in due time, and, having passed the gate, are in the immediate neighborhood of the palm-house, whose bulbous domes we saw just now from the river bank. It is as beautiful a piece of glass building as ever I saw, handsomely proportioned, and of noble outline. Its great size is somewhat concealed by its charming symmetry; but when we are within, the vast dimensions are realized. Beneath its central dome the tallest palms rise unimpeded. You peep through long vistas of broad green fronds and slender, bending stems: it broadens and reaches out on every side; the strange, exotic foliage rejoices the eye, and the warm, embracing atmosphere makes you feel that you are in the tropics.

To one who, like myself, pretends to no scientific knowledge of botany, and who, during these temperate summers and fitful winters, often hankers after the equator, the atmosphere of a thorough-going conservatory has a profound fascination. At one step I pass from the latitude of "the roaring forties" to that of Martinique or the Galapagos Islands. I unbutton my coat, and inhale deep breaths of air laden with the fragrance of the sun-lands. The heat is not enervating, but stimulating; for it is redolent with the life-giving emanations of plants that riot in luxuriance all the year round,—that know neither spring, autumn, nor winter,—whose multitudinous boughs were made to be the haunt of paroquets and monkeys, and amidst whose fern-enwrapped roots lurk lizards and gliding serpents. Here thrive the dark-skinned races of the torrid zone, innocent of clothes and civilization, seeking excitement not in the mutations of the stock-exchange or the scandals of society, but in trapping the alligator and shooting the jaguar and the antelope with arrows deadly with *curari*. Into the intricate depths of these jungles the fierce sun scarcely penetrates; the unstinted energy of his own rays has erected a barrier against himself. Here, when the rain falls, it falls in rushing torrents; when the wind blows, it blows a shrieking hurricane; when the lightning flashes, the whole dome of heaven is ablaze with passionate splendor. Here the stars poise and smoulder close to the earth, and the moon is brighter than the sun of hyperborean England. Sitting on a rustic bench hedged round with tapering palm-stems, and screened by leaves two or three of which

would carpet the floor of an ordinary drawing-room, I love to think of these things.

The enjoyment is perhaps enhanced by an occasional peep through the glass walls of the paradise, revealing the melancholy Britisher, close at hand in space, but thousands of miles distant in temperature, stalking rigidly about in overcoat and gloves. Then, too, the hot-house, while giving the charm and beauty of the tropics, dispenses with the inconveniences. Here are no coral-snakes to drop from the boughs down the back of your neck; no scorpions or tarantulas to crawl up your trousers; no apes to pelt you with cocoa-nuts; no rhinoceroses to toss you above the tree-tops; no tigers to disembowel you and bite your head off. On the contrary, everything is scrupulously neat and secure. The rich loam round the roots of the plants harbors nothing noxious; the asphalt walks that thread the thicket are clean and trust-worthy. Ever and anon you come upon a native of the place,—not a savage, painted in red and black stripes and with his bow-string drawn to his ear, but—a quiet and sober gardener in his shirt-sleeves, pruning a dead leaf or bough, or raking the mould round the roots of a new importation, or wielding a watering-pot. The place is quite still; the huge leaves hang motionless; the noise of a pair of steps being dragged into position resounds through the building; and, if you listen, you will at all times hear the pleasant trickling of water in some reservoir or other. If the terrors of the jungle are still too much for your nerves, you may be comforted by observing that each plant wears a label, painted on wood or enamelled on tin, describing its scientific name and habitat. It cost money to bring them here, and the very leaves of their twigs are numbered.

But there are other places to be visited besides the palm-house. As we emerge from its luxurious warmth into the cool English air, we see in front of us a large, circular pool, with broad, shallow flights of stone steps leading down to it, and English willows bending over it. Water-fowl swim and quack here, and children elude their nurses and get their feet wet. If we pass round to the other side, and then look back to the palm-house, we behold it inverted in the smooth mirror of the water,—a delectable spectacle. It was like a fairy palace already; but this shadowy duplication of it quite removes it from the material sphere, and makes it a lovely dream. Kew Gardens are full of such felicitous devices.

To our right are acres of yet unexplored hot-houses. We stroll towards them along eccentric paths, amidst beds of purple rhododendrons, geraniums, tulips, narcissuses, or hyacinths, according to the season; and everywhere is the matchless English turf, compact and flawless as velvet, and the leafy, overshadowing English trees. But let us seek the dwelling-place of the *Victoria Regia*. It grows, I believe, on the Amazon, which is as near the equator as one can well get; but latitudes are much mixed up in Kew Gardens, and this titanic water-lily is only a few rods distant. It basks on the surface of a pool, in an atmosphere of delicious warmth,—its leaves, each of the diameter of a dining-table, covering the water. Amidst these great green disks blossoms the flower, a nosegay of which would fill a farm-

wagon. It is said that the native Brazilian savages and Guianians walk about on the green leaves, and use them as rafts or stepping-stones to cross the lagoons. As to the flowers, though it is difficult to imagine anything more beautiful than our own water-lilies, yet these blossoms fairly surpass them, not only because they are a foot across, but because of the richness of the innumerable petals, and the gorgeous cluster of purple stamens that form the centre. And they fill the air with a fragrance vital and voluptuous. One longs to verify in his own experience that story about walking on the leaves,—not to speak of lopping off a flower or two to furnish one's study withal. But the quiet gardener, in his shirt-sleeves, though he appears to be absorbed in his work, has his eye on you; and you can do nothing but stand and stare in admiration.

The hottest of the hot-houses, if my memory serves me, were the cactus-house and the fern-house. The cacti were not beautiful, but they were grotesque and curious. There were none that I should have cared to handle. Their uncouth shapes and awkward putting-together seem characteristic of an epoch when Nature's handiwork was much less skilful and comely than it is now. They call up visions of forlorn wastes and desert solitudes. Their armature of thorns and prickles appears to indicate that they consider themselves very attractive and take unusual pains in the way of self-protection. Perhaps the donkeys of their time were unreasonably voracious. The modern thistle certainly indicates increased refinement of taste on the donkeys' part. Yet this ungainliness is occasionally redeemed by exquisite blossoms, of pale, pure hues, cropping out directly from the substance of the plant, without any pretence of a stem. One variety of cactus, in addition to its prickles, had provided itself with long white hair, which, surmounting its tall and rather meagre figure, gave it the aspect of an aged man of repulsive character. Among the cacti, though not of them, was a hideous plant (or it may have been a wax model of one) apparently of the fungus family. It grew on the bare sand or rock, and both flowers and leaves had a greasy, flesh-like surface, deeply tinted, and ornamented with poisonous-looking blotches. It was of immense size, the flowers being at least a foot in diameter; and if the Vale of Gehenna has any vegetation, I should expect it to be like this. A more depraved, diabolical plant it would be impossible to imagine. Its preposterous attempt to imitate the form and characteristics of ordinary vegetation made it still more revolting. The label described it as being very rare,—which is some comfort.

The fern-house, besides being hot, is dripping with moisture; and, the glass being tinged with green, the effect is somewhat like being submerged in a tropic ocean. The greenness of the ferns is vivid enough at any rate, but this artificial light adds such intensity to it that, after a few minutes, you are on the point of forgetting that there is any other color besides green in the world. The ferns are arranged in glass cases, or vivariums. There is nothing in nature to parallel their delicate and various beauty. I call it various; but it is chiefly beauty of form, and that, too, within comparatively narrow limitations. But the fineness, the subtilty, the changefulness of line, are endlessly charming;

they may have other uses, but if they had been made for pure beauty it would be use enough. They must have been of great æsthetic value to artists, especially to architects, decorators, and chasers of metals. The mediæval illuminators certainly made capital out of them ; reminiscences of their shapes render lovely the ornament of innumerable missals. As for the color, green seems to admit of more gradations than any other hue, as any one who has observed the woods in spring knows ; and of all others it is the most grateful and wholesome to the eye. With the rough grays and browns of the rocks it makes enchanting combinations. But, really, this moist fern atmosphere is too languorous and enervating ; we must escape into the outer world,—which, for a time, will appear strangely red, like that which astronomers suppose to be characteristic of the planet Mars.

It would take too long, even in imagination, to go through all Kew Gardens at this leisurely rate. Only, for splendor of color and voluptuousness of perfume, there is nothing comparable to the Conservatory, in which roses and all other bright-hued flowers are grouped and massed in sumptuous magnificence. The rose is England's flower: she has taken possession of it, as of so many other good things, without troubling herself to prove any title to it ; and there is nothing in her history or character to make her worthy of it. One can understand why Persia should claim the rose ; and in our own Southern States the houses are smothered with roses, and the air that flows from them is sweeter than incense. I have, it is true, gathered English roses in December ; and the houses of York and Lancaster wore roses which, red and white alike, were steeped in blood. But, if anything could justify England in her appropriation of the rose, it would be this rose-house at Kew, where criticism becomes impossible, and one can only gaze, and inhale, and love. Pink, white, crimson, golden, they cluster and triumph there : with their exquisite petals Venus and Mars might strew a couch worthy of an Olympian marriage. If love, romance, and beauty died out of human nature, this flower would bring them back ; and so long as it stays with us, we may be sure that life will not lose the glory that entitles it to immortality.

While meditating these matters, we might take a turn in the wood-house,—by which I mean the building containing specimens, polished and in the rough, of all kinds of woods from all parts of the world. Their gamut of color embraces all the hues of the rainbow, and many others ; and there are specimens of wood-mosaics that are inferior in beauty only to agate and marble. Or we may wander through the corridors and halls of the museum, which exhibits every sort of manufacture into which vegetable substances enter, including numberless fabrics of Indian or savage origin. One is surprised, after examining these things, that our little earth should be large enough to contain anything that is not more or less botanical.

But I set out to write about an American Kew, and my introductory reflections are monopolizing the entire space at my command. The truth is, of course, that no American Kew exists ; but it is pertinent, at the present time, to inquire whether there is any reason why it should not. America, I believe, is the only country of consequence that does

not possess an important botanical collection; while, on the other hand, there is certainly no country that has more natural advantages for creating and maintaining one. Were we to confine ourselves strictly to our own boundaries, we could make a magnificent showing; but we have the whole globe to draw upon, and we are so situated as to make this draft a comparatively easy affair. As to the scientific expediency of the enterprise there can be no dispute. The value of botanical study has always been recognized. The Dark Ages, whose enlightenment we are just beginning to appreciate, are greatly our creditors in this regard: the monks of the old monasteries, together with Albertus Magnus and other Hermetic philosophers who pretended to be absorbed in the pursuit of the Philosopher's Stone and the Elixir of Life, were at any rate diligent botanists, and, by their study and cultivation of plants, were the means of preserving countless specimens that would otherwise have been irretrievably lost, and which are of high value in medicine and otherwise. But for the energy of certain obscure botanists who lived and labored upwards of a century ago, the civilized world might now be eking out a miserable existence without either coffee or quinine. We had a narrow shave of it, as it was. In 1850, England and Holland became alarmed at the increasing price of cinchona, due to the rapid decrease of the forests in Peru. Seeds and seedlings were planted in Java; but they were of an inferior quality, and turned out poorly. At length England sent out Sir Clements Markham, who collected a quantity of healthy plants in Peru and despatched them to India, where a few of them arrived in good condition and were set out. The success was enormous; and there are to-day, in Bengal alone, upwards of five million plants of this useful vegetable, and myriads more are distributed all over the earth. As for coffee, our hopes of it came at length to rest upon a residue of three plants, which somebody whose name I have forgotten secured and carried away with him from its native habitat. Of these three, two died on the passage; but the third survived. But for that, how should we have fared at breakfast and after dinner? The unspeakable Turk, at all events, must have expired on his divan cushions long since: his cup of coffee is as vital to him as his hookah, which he owes to the magnanimous Raleigh.

There is no need, however, of multiplying instances to establish the value of botanical knowledge and the importance of encouraging and cultivating it. And yet we Americans, the leaders of civilization, have, after more than a century of national existence, done nothing towards keeping our end up in this respect. Surely the time is over-ripe for us to lay the foundations of such a collection as shall eclipse Kew itself and serve henceforth as a model to the world. The thing can so easily be done that it is a source of special wonder that it was not done long ago. It cannot fail, when done, to profit all concerned,—the promoters, the students, and the public at large,—who will not only have the grounds as a perennial pleasure-resort, but who will pick up inevitably a considerable acquaintance with botanical facts, which will redound to their health and prosperity in various ways.

Doubtless, once the idea has taken root, there will be Gardens all over the Union; but it behooves us in New York to be first in the

field, and to spare no pains to maintain the first place. Indeed, as old New-Yorkers will remember, Manhattan Island has already had a botanical plantation; though, owing to certain causes, it has disappeared and left no trace. It was when the present century was hardly more than a score of years old that one Dr. Hosack marked out a garden on the land now comprised between Forty-Sixth and Fifty-Sixth Streets and Sixth Avenue and East River. For several years the good doctor pegged away at his admirable hobby, and really achieved excellent results, although the popular mind was as yet scarcely educated to understand what he would be at. When, at length, he departed to that Paradise where botany and botanists have their apotheosis, he bequeathed his garden to Columbia College, on certain conditions. They were to be allowed to erect their new projected college buildings in a corner of the garden, and, in return for this grant, were to see to it that the plantations were kept in good order, and augmented as opportunity offered. I blush to say that the college, after taking advantage of the doctor's land, neglected to carry out his stipulation: they suffered the garden to fall to rack and ruin, until it became nothing but an unsightly wilderness; and then the real-estate cormorants came, and we see the result.

Nevertheless, the evil that men do, or the good that they leave undone, is sooner or later transmuted into somewhat conducive to the general welfare. Dr. Hosack's garden could hardly have been permitted to occupy its broad acres down to the present date; and perhaps it is better that it should expire in its infancy, instead of undergoing annihilation in the beauty of its maturity. Manhattan Island has no room for such an institution now. But there is in the immediate vicinity of the city, and under the jurisdiction of the Park Commissioners, a range of ground peculiarly fitted to be the site of an American Kew; and the Commissioners aforesaid have expressed their willingness to make a free gift of it to New-Yorkers, provided the latter, during the current year, show a disposition to give the wherewithal to render a Botanical Garden practicable.

Here is an opportunity evidently vouchsafed by Providence in the nick of time. The tract in question is none other than the Bronx Park, a delectable region, within four miles of Harlem (two miles nearer us than Kew to London), having protecting timber, fertile soil, low and high land, and traversed by the Bronx River, which furnishes in abundance all the water that can be needed.

It is by no means an unredeemed wilderness: much of it has been occupied from early times by wealthy residents, and the labor required to bring it into a suitable condition is thereby greatly diminished. In natural beauty it is unequalled in our neighborhood: it is more spacious than Kew, and surpasses it in all native qualities of soil and topography. The pecuniary value of this concession to the city, apart from other considerations, is not less than one million dollars: a more tempting offer has never been made to patriotic science, and, if it be not accepted on the spot, can never be expected hereafter. All that the wealthy citizens of New York have to do, in order to make an American Kew a certainty and bestow undying credit on their own

names, is to subscribe to a preliminary fund of two hundred and fifty thousand dollars as a guarantee of their good faith : this sum will be spent in giving the grounds their preliminary treatment and in laying the foundations of a work that shall be the foremost of its kind.

When American naturalists have been furnished with a place where they can study new plants and determine their qualities and uses under cultivation, investigate the animal and insect pests of the vegetable kingdom that have injured and still menace local plantations, devise means to aid in providing the growing population of the continent with good things to eat, and plenty of them, prosecute inquiries into the medicinal virtues of herbs, and, in a word, canvass the whole possibilities for good of the world of plants, we may expect to see our country enter upon a period of prosperity not unworthy of our hopes and promises. And many a young man who desires to use his brain and energy in some pursuit that may be useful to his fellows can receive here an instruction and a training more valuable than the curricula of the colleges, and embark in a profession obstructed by less competition than law, medicine, or literature.

A Botanical Garden, then, we should and must have; and now is the time to set it a-going. The Torrey Botanical Club of Columbia College (mark how the stings of conscience operate!) have already begun to work in its behalf; and subscribers to the fund ought not to be far to seek: the project, wherever it has been spoken of, has met with nothing but approval and encouragement. Such an enterprise is at least as well worth endowing as a town library or a millionaire university ; and, indeed, the only point that it seems necessary to emphasize in this place is the importance of giving the preliminary fund at once. It will, of course, be only the nucleus of many millions more to come; but, unless it is assured now, the offer of the free site will be withdrawn, and New York will look very foolish. Suppose, too, that Philadelphia, or Chicago, or San Francisco, or Boston, were to profit by our procrastination, and cut in before us?—But surely this spur is not indispensable to our activity! Let us achieve our Garden because it is a useful and noble thing to do ; and then the rest of the country may follow in our wake.

Julian Hawthorne.

THE WORST OF IT.

AH, faithless! if Death had bereaved me, at least Death had left me the past,
With its strange wild glory of joy that was all too keen to last,

And that glory had lit up the future,—the sad years yet to be;
But now there is naught in the future, as naught in the past, for me:

I have tracked one skulking secret, I have dragged it shrieking out,
And the joy of the past is fulfilled with the shame and the horror of doubt.

Edward Jay.

Pop. Sci. Month. June 1900

THE NEW YORK BOTANICAL GARDEN.

By DANIEL TREMBLY MACDOUGAL,
DIRECTOR OF THE LABORATORIES.

A BOTANICAL garden is a museum of plants in the broadest sense of the term, and its chief purpose is to represent, by means of living specimens so far as possible, the principal types of the vegetation of the globe. It is obviously impossible to cultivate on any small area more than a few thousand of the quarter of a million of species in existence, and hence the plantations are supplemented by preserved specimens to illustrate the forms, which, by reasons of limitation of space, climate and soil, cannot be grown in the locality. In addition the species which formed the vegetation of the previous geological periods are represented by fossil specimens completing the history of the plant world so far as it is known, and yielding suggestions as to the descent of the present types.

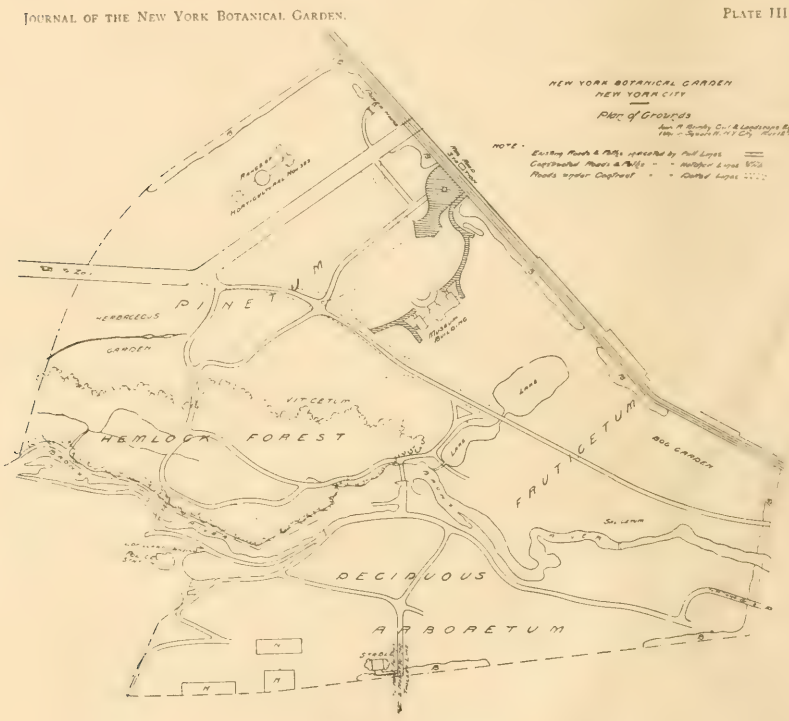
Two general educational purposes are served by an institution of this character. Its collections are arranged to present information on the form, relationship, mode of life, habit and general biological character of the principal types of vegetation, in such manner as to be capable of comprehension by persons unacquainted with the technical aspects of the subject. Further interpretation of such facts may be made by means of books, journals, and lectures devoted entirely to this phase of the subject.

The material accumulated for the exploitation of popular knowledge of plants also affords an excellent basis for the induction of students into the more strictly scientific aspects of botany, and when supplemented by laboratories furnished with apparatus, miscroscopes, and other instruments of precision, the activities of these students may be carried beyond the frontiers of the subject in the investigation and discovery of new facts and phenomena. This extension of the boundaries of knowledge concerning the plant world may be carried on to advantage, only when a library is at hand, which contains all of the more important literature bearing upon the subject. The descriptions of the results of such researches should be made in publications devoted exclusively to this purpose, in accordance with the practice of all the more important botanical institutions in the world.

The general scope of the New York Botanical Garden has already been described by the writer in a previous number of this magazine (January, 1897). The greater part of its actual construction and or-

ganization has taken place in the last three years, and it has now entered upon the discharge of its chief functions.

The Garden comprises two hundred and fifty acres of land in Bronx Park, in the City of New York, which was set aside for that purpose by the Department of Public Parks in 1895. A fireproof museum building of stone, brick and terra cotta, 308 by 110 feet, has been erected for the Garden by the city in the western part of the grounds, near the Bedford Park Station of the New York Central Railroad. The building has a basement floor and three stories, with a total

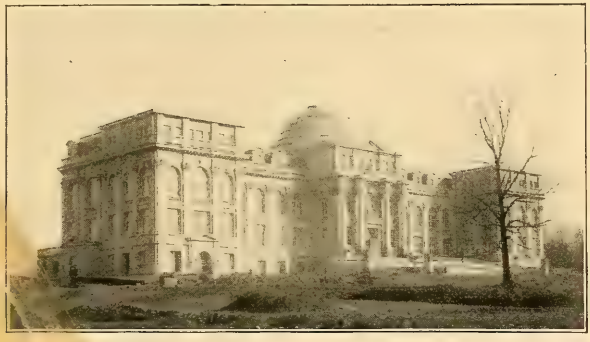


MAP OF THE GARDEN.

floor space of nearly two acres, and a window area equal to half that of the floor area. The basement contains a lecture theater capable of seating seven hundred people, two large exhibition halls, preparation rooms, constant temperature laboratory, offices and storerooms. The first floor is devoted to a collection of economic plants, and the temporary installation of useful products in the way of foods, drugs, timbers, woods, fibers, gums, waxes, resins, oils, sugars, starches, poisons, utensils, etc., gives hints as to the great diversity of uses that may be made of vegetable products, together with an illustration of their method of preparation and their derivation.

The second floor is given over to an exhibit of types of all of the more important families and tribes of plants, from the simplest and most minute, to the highest and most complex. Specimens, models, fruits, seeds, drawings and photographs are used to bring the principal facts clearly before the observer. A set of swinging frames running parallel to the cases containing the types of the flora of the world, are used to display specimens of the plants found within a hundred miles of New York City. A number of special microscopes have been constructed for the purpose of forming a perfect exhibit, which will enable the visitor to see some of the more salient features in the minute structure of some of the plants in the cases.

The third floor contains the library, herbarium and laboratories. The library occupies a stack room extending to the rear of the middle of the building, two small storerooms and a large circular reading-room, under the illuminated dome. Here are assembled the botanical



THE MUSEUM.

books of Columbia University, as well as those accumulated by the Garden, now numbering more than eight thousand volumes, with no reckoning of unbound separates and pamphlets. The collection of botanical periodicals is nearly complete, and the library is especially rich in literature concerning the mosses, ferns, and the flora of North and South America.

The main herbarium occupies a room in the east wing, eighty-five by forty-seven feet, and connected with it are storerooms and offices adequate to its administration. Windows on all sides of the main room and skylights give ample illumination. The number of mounted specimens on the shelves is not less than three quarters of a million, including the herbarium of Columbia University, which is deposited here in accordance with the agreement between the two institutions. The collection is especially rich in fungi, embracing the collections of Ellis and other eminent mycologists. A large amount of material of

great historic value in connection with the work of Dr. John Torrey and the earlier botanical development of America is included. Accessions are being made to the herbarium at the rate of fifty to a hundred thousand specimens annually.

The laboratories consist of a series of rooms facing northward and westward, with special facilities for taxonomic, embryological and morphological investigations. Physiological and photographic dark-rooms, the experiment room for living plants and chemical laboratories offer especially ample opportunities for the record and development of practically all phases of plant physiology. The laboratories, library and herbarium are open to the graduate students from Columbia

IN THE FOREST.

University, in addition to those from other institutions of learning who may register directly at the Garden. The latter, in return, have the privileges of students at Columbia University.

A weekly convention of all of the workers in botany in New York City is held in the museum, at which the results of recent researches are given or an address is made by an invited speaker from out of the city.

The area of the Garden presents a very irregular topography, comprising, as it does, a half mile of the valley of the Bronx River, low marshes and swamps, artificial lakes, open glades, with heavy peaty soil, upland plains with gravelly sandy soil, granite ridges, and about seventy acres of natural forest. About forty acres of this forest consist of a dense grove of hemlocks, which has never been seriously

disturbed by the hand of man. It is truly remarkable that the City of New York should include within its boundaries a primitive forest of this size, and this invaluable feature is to be preserved forever by a special contract between the Garden and the Department of Public Parks. Since a hemlock forest is a climactic formation, and is not replaced by any other growth unless cut down, it may be expected to endure through the present geological epoch, barring the accidents of flood, storm and fire. The great diversity of conditions offered by the natural features of the Garden gives it a very rich population of indigenous plants. A census of the ferns and seed-plants at the time the tract was converted to its present purpose showed nearly a thousand species.

THE NORTH MEADOWS.

The entire area has been handled most sympathetically by those in charge of the architectural features of the Garden. The buildings were erected in the more open western part of the grounds, which offered the least valuable landscape features, and the surface around them has been improved by plantings. The natural beauties of the tract have been most zealously guarded from disturbances of all kinds. The attractive panoramas of wild woodland and stream offered to the artist and lover of nature have been left absolutely untouched, but made more valuable by increased ease and safety of access.

A number of special biological groups of plants have been established in suitable places in various parts of the Garden. The trees are in the arboretum east of the Bronx on the side and summit of a long ridge; un-

assorted and reserve material of all kinds is kept in the nurseries on the eastern slope of the same ridge; the salicetum is established on the border of the marsh in the northern end of the Garden, giving the willows and poplars the conditions under which they grow best. The fruticetum occupies an adjoining upland plain underlaid with gravel to a depth of twenty feet, affording space for the cultivation of a large number of shrubs, while the conifers are located on slopes to the westward of the hemlock forest. The viticetum is along the western edge of the forest, and the trellises of logs and timbers, extending for a length of six hundred feet, give suitable support to the

THE WATERFALL.

vines. The herbaceous plantation occupies an open glade to the westward of the forest, and lies between two granite ridges. It is traversed through the middle by a small stream widened at places into lagoons for aquatic forms. About twenty-two hundred species are now in cultivation in this plantation. The wide border plantations which are established along the boundaries also offer opportunities for the growth of a great variety of trees, herbs and shrubs.

The horticultural houses, also erected by the City for the Garden, are located in the western part of the grounds at some distance to the south of, and facing, the museum. A palm-house, with a total height of dome of ninety feet, is the central feature, from which lower ranges extend on either side, making a total length of front of five hundred and twelve feet. The horticultural houses, as well as the museum, are heated by

steam furnished by a power house beside the railroad on the extreme edge of the Garden.

The collections of living plants in the plantations are arranged in the same system as the synoptic collection in the museum. Every plantation contains species of similar habit, and the horticultural houses are used for the cultivation of forms which may not endure the outdoor climate of this locality. Not only are the plants from warmer zones grown under glass, but when it is desired to develop native species out of their season, they may be forced and brought to full development and bloom in the winter.

IN THE HERBACEOUS PLANTATION.

The construction of driveways and paths is being prosecuted by the Park Department with all available funds at their commands.

Public appreciation of the natural beauties of the Garden, and of the phases of botany illustrated by its collections has been most gratifying, as shown by the great and constantly increasing number of visitors. The series of popular lectures given in the museum on Saturday afternoons have been well attended. The Journal of the Garden, which serves as a means of communication with its members, brings to the notice of its readers interesting facts in botany, horticulture and forestry, and records a constantly swelling list of gifts of books, specimens and plants.

The library, herbarium and laboratories have been open for only a few months, yet twenty-two students have taken advantage of the

facilities thus afforded during the collegiate year now closing. Investigations of importance have been carried forward by these students, by members of the staff, and by the members of the staff of Columbia University. The results of some of these investigations have been published in the Bulletin of the Garden, which also contains the official reports of the organization. Papers written by members of the staff or students are reprinted from the periodicals in which they appear as contributions, while a fourth series of Memoirs has been found necessary for the presentation of papers of great length.

Not the least important of the investigating functions of a garden consists in its participation in the exploration of remote or unknown parts of the world in an effort to obtain a better knowledge of the plant population of the earth. During the brief period of its activity the

HORTICULTURAL HOUSES.

Garden has already carried out work of this character in the Rocky Mountains and in Porto Rico.

The ordinary work of the Garden is maintained by the income from its endowment fund, by the annual dues of its members (now numbering over eight hundred) and by an annual appropriation by the City. Its board of managers is authorized to hold and administer trust funds, and it is hoped by the aid of gifts or bequests for special or general purposes to expand its usefulness in directing investigation. Already it has been favored by a bequest of a considerable sum of money by the late ex-Chief Justice Charles P. Daly, which may be devoted to any purpose determined by the board of managers.

BOTANIC GARDENS

BY

D. T. MacDOUGAL

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Botanic Gardens

D. T. Mac Dougal

THE TERM *botanic garden* in its broadest sense is used to designate a plot of ground on which is grown a collection of plants, which so far as possible under the prevailing climatic conditions, should represent as many of the principal forms of vegetation as is possible. It is obviously impossible to bring together at one point on the earth's surface more than a fraction of the living plants of the globe, since the number known to exist at the present time is nearly half a million species. The largest collection of plants which it has been possible to grow in one locality is that of the botanic garden of Paris with its fifteen thousand species. In consequence of this limitation, due chiefly to substratum and climate, the living plants are generally supplemented by prepared specimens of fossil and contemporaneous forms, in such manner as to present more completely the vegetation of the globe. Furthermore the living plants should be so assembled as to demonstrate the descent and relationships of the several important groups, distribution over climatic and geographic zones, as well as their principal biological adaptations to the factors which surround their natural habitats.

In addition to this strictly natural method of treatment, it is also customary to illustrate by groups, the forms which have become of special interest because of their food furnishing, textile yielding, medicinal properties, or other economic value. At the present time the economic feature has become subordinated to the other—biologic aspects of plant life in garden organization, although it is to the first named feature that these institutions owe their origin.

The first botanic gardens were formed by the Benedictine monks of Italy in the ninth century, and were devoted entirely to the growing of "simples". This continued to be their func-

tion until near the close of the sixteenth century (1560) when botany in its scientific phases received its first contribution in the writings of Conrad Gessner. Since that time the purpose and usefulness of the botanic garden have steadily broadened with the development of the science, until at the present time all the institutions devoted to the important branches of the subject are supplemented by gardens especially adapted to their requirements. It is only when a botanic garden is equipped with laboratories for the furtherance of investigation and sustains an organic relation to a school or university, that it may be said to attain its highest possibilities of usefulness. Conjointly and partially in consequence of its long existence near educational centers, the botanic garden has become, instead of a simple field for the cultivation of thousands of species of plants, a laboratory where the biologist may demonstrate the known principles governing the development of plant life, as well as penetrate deeper into the history of this, one of the two great groups of living things. The botanic garden is not, however, a laboratory for the scientist alone, but for the landscape artist as well, who may dispose of its masses of plant forms with a feeling of regard for their artistic value, making it a most efficient means of cultivation and gratification of the public taste. In many of the better known gardens of the world this æsthetic feature has become a prominent or predominant idea. This is especially true of those formed in the greater cities on a foundation of special endowment either private or governmental.

A somewhat anomalous combination of economic and æsthetic purpose is offered by the famous Royal Garden of Kew, England, and its numerous branches in the English colonies. Here the great central garden with its six thousand species of growing plants, magnificent conservatories and beautiful driveways, has become almost entirely a pleasure park which is visited by half a million people yearly, while the greater part of the economic and scientific work of the organization is performed by the herbarium connected with it. The subordinated branches in the various parts of the empire devote almost their entire resources to testing the economic qualities of plants and to the local dissemination of information thus derived. It is of

course to be understood that while the chief purpose of the Kew system is economic, it has made a long series of contributions of very great importance to systematic botany. I quote the following paragraph from an authorized guide to the Kew grounds:

"It may be mentioned that Kew is not only a great educational establishment and pleasure resort, but also the recognized center of the various botanic gardens throughout the Empire. The part it has played in the introduction of the cinchona into India, and in fostering various other important industries, is well known. It may well be described as the greatest botanical clearing house of the Empire. To it a large number of plants are constantly being forwarded from all over the world to be named, for which purpose a staff of botanists is provided, and the collection of dried plants, or herbarium, as well as the large botanical library, is unrivalled throughout the world. In the same way the collection of cultivated plants and trees, both hardy and exotic, is the most perfect in existence."

When organized chiefly for teaching and research the botanic garden differs in many essential particulars from that described above. From this point of view, and with regard to the advantages of geographical position and biological possibilities perhaps the most important botanical garden in the world is that of Buitenzorg, in Java, established by the government of Holland in 1817. Originally founded for the purpose of testing the economic value of plants indigenous to the Dutch colonies in the East Indies, and for the distribution of seeds, plants, etc., after the customary manner of such institutions, it has widened its scope and developed its facilities until almost all branches of purely scientific and applied botany may be pursued to advantage within it. The real value of this garden may be better understood when it is stated that the science of botany in its present elementary condition rests upon researches carried on principally with plants indigenous in the north temperate zone and such tropical plants as may be grown in conservatories. And the solution of some of the more important problems of biology is to be attained only by the study of these tropical plants in unlimited number and under natural

Plate I. VIEW OF LAKE IN BOTANIC GARDEN, BUITENZORG, JAVA

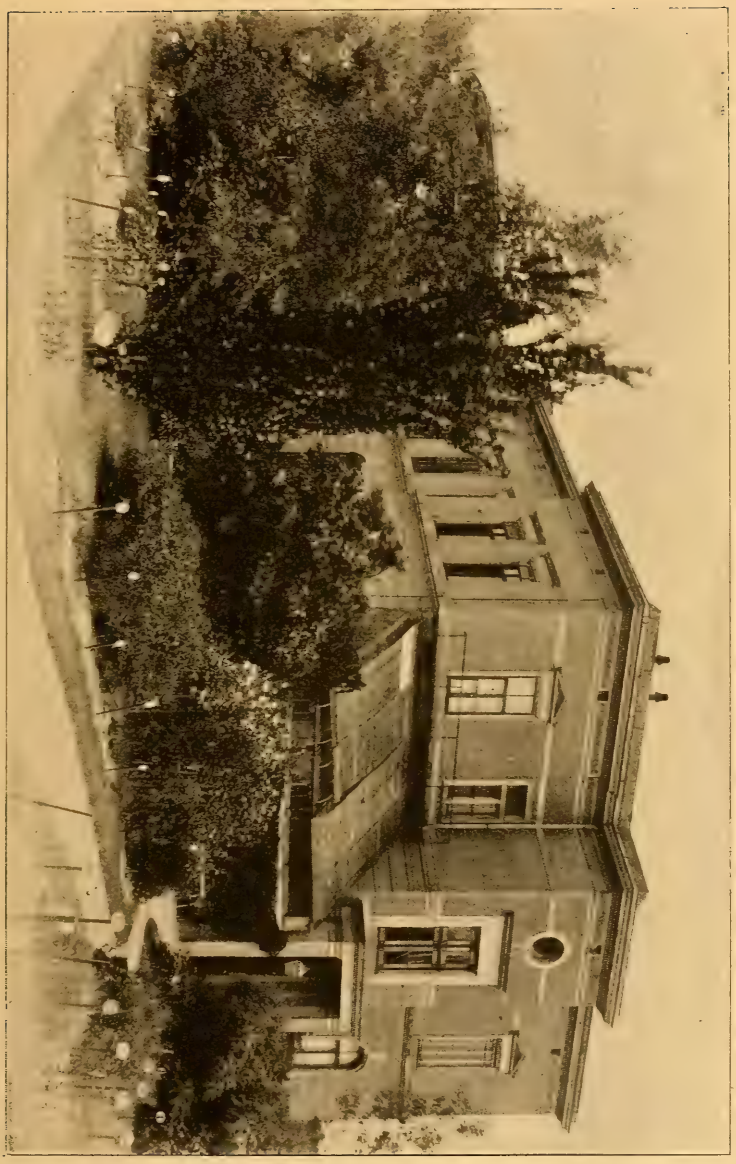

Plate II. THE BOTANIC INSTITUTE, LEIPSIC

conditions, which in the main have been studied only amid artificial surroundings. At Buitenzorg the eleven hundred acres of ground comprised within the garden occupies territory from near sea level to a height of about eight thousand feet, and perfectly suitable climatic conditions can be found for all the nine thousand species growing within it. Biologically this would be equivalent to a strip of territory at sea level extending from the tropics northward as far as Minneapolis. In addition to many other advantages, the abundant water supply in the streams and lakes within its limits furnish abundant facilities for the study of aquatic plants. In Plate I is shown a view of an island in one of the large lakes devoted to this purpose, in the main grounds. It is of course unnecessary to say that this institution has furnished opportunities for many important discoveries, and that it has become a Mecca for the botanists of the world. The list of names of investigators who have carried on work here includes a large number of those most prominent in the development of botanical science.

The great age of the gardens of continental Europe make them objects of great interest since many of them antedate the foundation of botany as a biological science. That at Bologna was formed in 1568, at Leyden in 1577, at Montpelier in 1593, at Giessen in 1605, at Strassburg in 1620, at Jena in 1629, at Paris in 1633 and at Upsala in 1657.

As has been previously mentioned, nearly all of the older gardens began with the cultivation of medicinal or economic plants, and their development until the present time has been influenced by the peculiar local conditions surrounding each of them, the corresponding development of biological study at the time of their most vigorous expansion, and the particular part assumed by the botanists in charge of them, in scientific investigation. As a result, the gardens of Europe are each highly specialized and their chief purposes may be found through the entire range of usefulness from pleasure parks to institutions for research. In those devoted to the last named purpose the specialization has been carried to such farther extent that generally, in each of them, facilities are afforded for research in one or at least a few lines only, of purely scientific or applied botan-

ical science. Institutions of this character are generally under the care of a somewhat independent staff of administration and instruction and are supported by separate appropriation or endowment, although they sustain a relation to the university somewhat similar to that of the department or school to the American university.

The greater part of the history of the development of botany lies within the botanical institutes of the gardens of Germany, and prominent among those distinguished by the results they have accomplished as well as their present activity may be mentioned those of Munich, Würzburg, Tübingen, Göttingen and Leipsic.

In such institutions the actual number of growing plants is comparatively small, but it consists of species which may be of possible service in the solution of the problems under investigation, and only in the larger ones is an attempt made to illustrate the principles of geographic botany. The actual area enclosed rarely includes more than a few acres, and beside the ground for growing plants it also furnishes the site for the laboratories and other facilities which constitute an "institute". Plate II. is a view of the botanical institute at Leipsic, which at the present time occupies a prominent, if not the foremost place in the amount of valuable results attained.

The wisely-selected but not extravagant equipment, the ease with which skilled labor may be secured, the fixed and liberal policy of the German state toward scientific research, and the accurate and skillful management of these institutes by the scientists who have had them in charge from time to time, have made them most powerful factors in pushing forward the frontiers of knowledge of the biology of plants. Very naturally, many of these gardens and institutes have become of great direct and personal interest to the student of natural science, not only because of their high efficiency, but also on account of the historic value of certain features. In many instances the material, perhaps the actual growing plants, upon which epoch-making investigations have been made, are still intact. Thus at Munich is a very complete collection of cacti upon which important work in the evolution of plant forms has been per-

formed by Gœbel, and a number of anatomical preparations by the elder Hartig, which were made before the current idea of the cell had been reached, are prophetic in their accuracy of representation of certain cell structures. A complete series of microscopes, representing the entire development of that important instrument in research, in all branches of natural history, is to be seen at Tübingen. In one of the enclosures at this place is a rockery five hundred feet long and twenty feet wide, upon which are growing two thousand species of Alpine plants. The nicety with which plants of this character select slope, moisture, soil and sunlight in their natural habitat on mountain sides and in northern latitudes can scarcely be comprehended by one who has not seen them so growing. It is by such groups of living forms that contributions looking to the solution of the greatest questions in biology may be made, and their formation requires such a degree of skill in the gardener's art and such an intimate knowledge of plant life as to be possible only for one with the instincts of a naturalist.

Botany has been given an important place on the college curriculum in America scarcely more than sixty years. In comparatively recent years a few gardens have come into existence, nearly all of which are still in a state of rapid development. During this period of flux they have been able only to afford facilities for general elementary instruction, and to make possible original work in the classification of our native plants—a line of research which has been carried on more or less steadily since the earlier settlements were made on this side of the Atlantic. At the present time a few have begun to offer opportunities for higher teaching in the more important branches of botanical science. Among these may be mentioned the Missouri Botanical Garden of St. Louis, connected with the Washington University, the Botanical Garden and Arnold Arboretum of Harvard University, and the Botanic Garden of New York, now in process of formation and to be connected with Columbia College. The purpose of the Missouri institution may be best illustrated by the following quotation from the will of its founder,—"with the view of having for the use of the public a botanical garden easily accessible, which should be forever kept

up for the cultivation and propagation of plants, flowers, fruit and forest trees, and other productions of the vegetable kingdom; and a museum and library connected therewith, and devoted to the same and to the science of Botany, Horticulture, and allied objects." It was formally connected with the Washington University in 1885. By a recent announcement of the director such additions are being made to its growing collection of plants, library, herbarium, and apparatus as will enable a properly equipped investigator to carry on work in any line of pure and applied botany. At the present time the total value of the garden and its estimated endowment is estimated at one and one-half million dollars and its gross income at one hundred and thirty-five thousand. The herbarium contains more than two hundred and thirty thousand specimens, and the library about eighteen thousand volumes of carefully selected works. This institution will doubtless hold an important position in the furtherance of investigation in America.

The Botanical Garden of Harvard has an area of seven acres and contains about five thousand specimens of growing plants, so arranged as to facilitate research to some extent in various lines. The herbarium of seed-forming plants in direct connection with the garden contains over two hundred thousand specimens and the library includes about nine thousand volumes of books and pamphlets.

The Arnold Arboretum covers an area of one hundred and sixty acres and is devoted entirely to such trees and shrubs as may be grown in the open air. In direct connection with the Arboretum is a herbarium, museum and library, for the purpose of aiding study and research in arboriculture, forestry and dendrology. The arboretum is also open as a public park to the city of Boston. In addition to the facilities mentioned, the university is also provided with a series of laboratories, a museum, an extensive library and herbarium for research in cryptogamic plants.

The New York Botanical Garden, which is the most recent addition to botanical institutions, is in process of formation on an area of two hundred and fifty acres in Bronx Park. By private subscription a quarter of a million dollars has been

raised as a permanent endowment fund, and the city will erect buildings for museum, library and laboratories at a cost of half a million. The scope of this institution may be best illustrated by the following quotation from the act of incorporation: "to be located in the City of New York, for the purpose of establishing and maintaining a botanical garden and museum and arboretum therein, for the collection and culture of plants, flowers, shrubs and trees, the advancement of botanical science and knowledge, and the prosecution of original researches therein and in kindred subjects, for affording instruction in the same, for the prosecution and exhibition of ornamental and decorative horticulture and gardening, and for the entertainment, recreation and instruction of the people." The herbarium of Columbia College, comprising more than six hundred thousand specimens, as well as the botanical library, will be housed in the museum in such manner as to be most easily accessible to those fitted and desirous of carrying on independent work. The conditions of organization are such that a high efficiency for the entire equipment will be at once attained. The establishment of this garden marks an important step in the development of botany in America.

BOTANIC GARDENS.

BY

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I.—ORIGIN AND GENERAL ORGANIZATION.

THE term *botanic garden* is used to designate a limited area of ground on which is grown a collection of plants of a large number of species, arranged in a manner that will subserve some educational, æsthetic, scientific, or economic purpose. At the present time the utilitarian feature embraces the chief design of but few gardens, yet it is to the economic purpose that these institutions owe their origin. It will be interesting in this connection to note the successive changes of organization by which these institutions, at first as directly practical as possible, have come to subserve the most complex and highly scientific uses.

After the discovery of the medical properties of plants, it must have followed, in course of time, that representatives of the species to which remedial properties were attributed should be collected and grown in some place conveniently and readily accessible as need demanded. The last step did not immediately follow, however, since, among the conditions which were earlier supposed to influence the potency of medicinal herbs, the locality in which grown and the mysteries attending their collection were of the greatest importance. The first authentic record of the introduction of medicinal plants into cultivated plots of ground dates no further back than the time of the elder Pliny (23–79 A. D.), who writes of the garden of Antonius Castor, at Rome, in which were grown a large number of medicinal plants. This step may have been taken much earlier by the Greeks, Chinese, or Mexicans, however. Later the Benedictine monks of northern Italy paid great attention to the growing of remedial herbs, and devoted an important proportion of the monastery gardens to this purpose. This practice was also carried beyond the Alps, and in 1020 a

garden was in existence at the monastery of St. Gall, in Switzerland, a few kilometres distant from Lake Constance, which contained sixteen plots occupied by medicinal plants. A garden of this character was founded in 1309, at Salerno, and another in Venice in 1330. In 1309 the Benedictine monks founded an academy called "Civitas Hippocratica" at Monte Cassino, in Campania, which appears to the writer to be among the earliest, if not the first, school of medicine, and established in connection with it a "physics garden." Two centuries later, courses of lectures on the "simples," as the unmixed preparations of herbs were termed, were given in the greater number of Italian universities, under the title of "lectura simplicium," by the professors of anatomy

VIEW OF THE LABORATORY IN THE OXFORD BOTANIC GARDEN. After a photograph.

and surgery. It is interesting to note that the laboratory method of handling the course in "cognitio simplicium" was not introduced until the establishment of the botanic garden at the University of Padua, when, in addition to the lectures, exercises in the demonstration of remedial plants growing in the garden were given under the title of "ostencio simplicium."

The sixteenth and seventeenth centuries witnessed the foundation of many gardens in England, France, Germany, Holland, and Sweden, some of which have had a continuous existence to this day. The garden of Bologna was founded in 1568; Leyden, 1577; Leipsic, 1579; Montpellier, 1596; and Paris in 1597. The last named was organized for the purpose of determination of "what

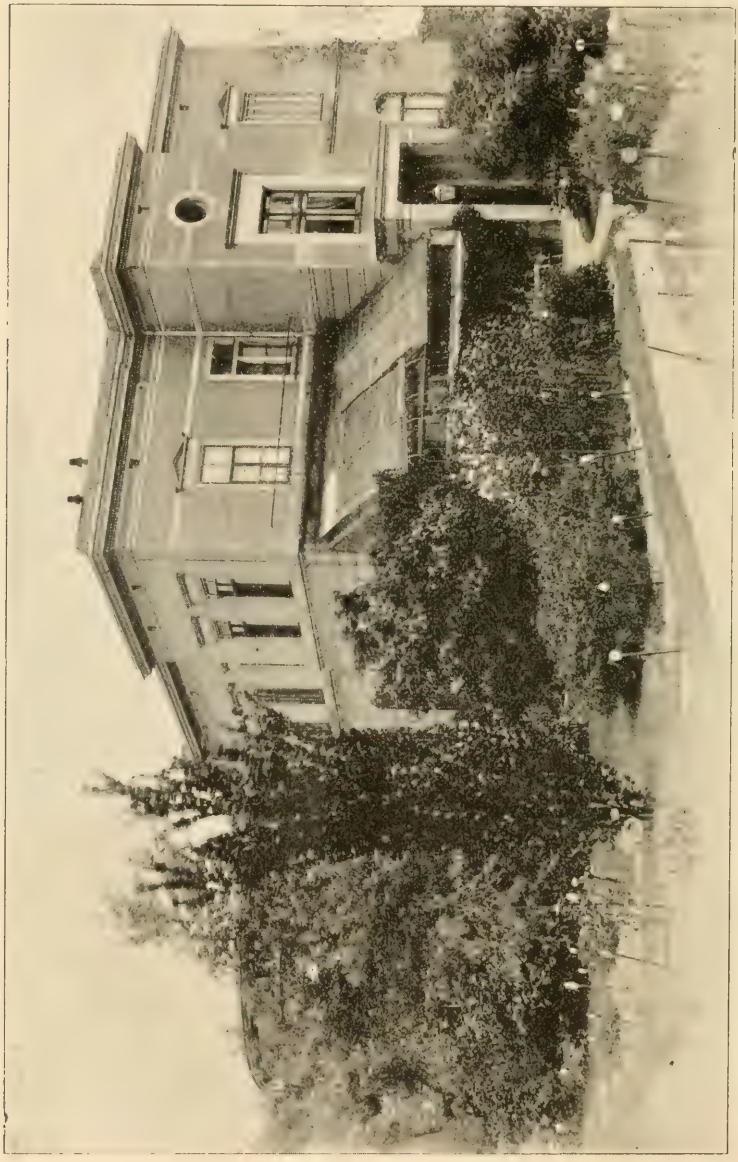
variations were possible in the style of bouquets worn at the royal courts." Then followed the establishment of the gardens at Giessen in 1605, Strasburg in 1620, Jena in 1629, Oxford in 1632, Upsala in 1667, and Chelsea in 1680.

The Oxford garden is the oldest in England, and a curious feature in its organization is that during its entire term of existence—two hundred and sixty-four years—it has occupied leased ground. It owes its existence to the munificence of the Earl of Danby, who, besides making such alterations in the surface as to secure it from overflow, erected the wall that still incloses it, at a cost of five thousand pounds. The portion of the garden shown in the view of the Botanical Laboratory exhibits the formal style of planting which prevailed in earlier times.

The Chelsea garden is situated near the Thames, about two miles south from Hyde Park. It was formed by the Apothecaries' Guild of London, for the growth of plants for commercial purposes. Later it was converted to its present use, that of furnishing material to illustrate lectures in pharmacy and medicine. Surrounded on all sides by brick buildings, and shaded by smoke and fog, the rectangular plots of officinal plants exhibit very strikingly the deleterious effects of an atmosphere laden with acids. The would-be visitor to this quaint old place must arm himself with an admission card obtained from the Apothecaries' Society, and from the creaking formalities attendant upon the granting of such permission by unaccustomed but polite officials it may be inferred that the casual sight-seer does not often find his way into the place.

During the period inclusive of the foundation of the last-named institutions plants began, however, to be considered from another point of view—from a strictly scientific standpoint, and as independent organisms. While the Aristotelian school studied plants in a manner closely approaching that of the present time, yet this beginning of biological science had no logical continuation, and during many succeeding centuries was completely lost to sight. In the latter half of the sixteenth century two new forces were manifest in the development of these institutions. Many of the wealthier class who had private gardens began to enlarge them by the addition of species because of their rarity, or because they were brought from some foreign country, and in many instances special collections were made chiefly for this purpose alone. Thus it may be seen that beyond the useful properties of plants, perhaps the first truly scientific idea of them concerned in a crude way some of the principles of geographical distribution. This phase of the subject received an increasing attention, and finally assumed form and order upon the introduction of the Linnæan system of classification into Germany and that of Jussieu into France.

Before this, however, a still more important development in the method of study of plants had ensued, as is shown distinctly in the botanical writings of the latter half of the sixteenth century. The all-important fact of the natural affinities of plants



THE BOTANIC INSTITUTE AT LEIPSIC, SHOWING ENTRANCE FROM GARDEN, AND GLASS COMPARTMENT FOR USE IN EXPERIMENTS WITH LIVING PLANTS. After a photograph. Reproduced by permission from the Minnesota Magazine, vol. ii, No. 1, 1895.

had gradually assumed distinctness—an idea not within the grasp of any one of the herbalists of the time, whose accumulating and repeated descriptions of individual species gave rise to

the perception of resemblance and difference in forms, and finally to the idea of natural relationship. This idea finally became paramount: "All the foreign matter introduced into the descriptions of plants by medical superstition and practical considerations were seen to be of secondary importance, and were soon thrown aside in the effort to establish a natural system of classification."

At the time of this "renaissance" of botany the gardens represented the ideas of geographical distribution and classification in addition to the practical aspects of the subject. With the development of physiology and morphology the ideas thus brought into prominence have found expression in the gardens, and the purposes and usefulness of these institutions have steadily broadened until all the more important phases of the subject are more or less represented in the greater majority of instances.

In addition to the scientific and practical uses enumerated above, the botanic garden has become a laboratory for the landscape artist, who may dispose of its masses of plants with a feeling regard for their artistic value in outline and color, making a most effective means of cultivation and gratification of public taste. In many of the better known gardens, especially those located in the great cities, this æsthetic feature has become a very prominent and in many instances the predominant idea.

Only when a botanic garden is equipped with laboratories for the furtherance of investigation, and sustains an organic relation to a school or university, may it be said to attain its highest possibilities of usefulness, in the demonstration of the principles governing the nature and development of one of the two great groups of living things. When designed for this purpose the collection of growing plants should represent as many of the principal forms of vegetation as is possible. Since the probable number of living plants is estimated at half a million, it is obviously impossible to bring together in any restricted area more than a fraction of this number. A census of the flora of the section of Bronx Park in New York, inclusive of about two hundred and fifty acres, which is to be converted into a botanic garden, showed that nearly a thousand species of ferns and seed-forming plants were to be found on that area, only a small number of which were introduced. Of these thousand species many were represented by thousands or perhaps hundreds of thousands of individuals. In the conversion of the tract into a botanic garden, the gardener will remove all but a few dozen, or perhaps a few hundreds, of each species, which will be confined to certain designated limited areas. In this way he will relieve each species from the competition of its neighbors, and so far as possible from the ravages of insects and animals—the most telling factors in the struggle for existence—and obtain space for the introduction of a large num-

ber of species. If these conditions alone determined the flora of a region, the number of species which could be grown in a garden would be determined only by its size and the number of plots it might contain. It is found, however, that the substratum and climate offer rigid limitations to an extension of the flora which may be grown out of doors in any locality. The gardener partially overcomes this limitation by the use of glass houses, where plants from nearly all parts of the world may be grown in specially prepared soils, and kept at temperatures resembling those of the natural habitats of the plants. But under such conditions

The Main Palm House of the Royal Gardens at Kew, with Lake in Foreground.

it becomes extremely difficult to properly adjust the moisture and light, and only a comparatively small addition may thus be made to the flora of a garden. The conditions described above are such that it has not been found possible to grow in one place more than fifteen thousand species of the higher plants. It will be found, moreover, that a large number of the species included are not able to attain normal stature and appearance, and will thus be useless in representing the form intended.

In consequence of this limitation of the number it is customary to supplement the living plants by collections of prepared specimens of contemporaneous and fossil forms, in order to represent more completely the vegetation of the globe. The living as well as the prepared plants are generally so assembled as to demonstrate the descent and relationship of the different groups, distribution over climatic and geographic zones, as well as their principal biological adaptations to the factors to be met in their native habitats. In addition to this strictly natural method of

treatment it is also customary to illustrate by proper groups the forms which have become of special interest because of their food-furnishing, textile-yielding, medicinal, or other economic value.

VIEW OF MAIN PORTION OF TEMPERATE HOUSE OF THE ROYAL GARDENS AT KEW. In process of repair. After a photograph.

In order to accomplish these purposes a suitably equipped garden must contain, besides the necessary facilities for growing plants, museum buildings arranged for the display of prepared specimens, and if it designs to afford opportunities for research it must also be furnished with a library and laboratory facilities.

There are in the world more than two hundred institutions designed as botanic gardens, a large proportion of which are devoted to the cultivation of decorative plants, or subserve the use of pleasure parks, while only a small number are organized on the broader basis of the needs of the branches of botanic science. Thirty-six of these institutions are located in Germany, twenty-three in Italy, twenty-two in France, thirteen in Austria-Hungary, twelve in Great Britain and Ireland, and ten in the United States.

One of the most widely known is the Royal Botanic Garden at Kew, located on the south bank of the Thames, six miles from Hyde Park. The beginning of the Kew Gardens may be dated from the formation of the exotic gardens of Lord Capel in 1759. After a long series of changes in ownership and purpose, additions and alterations in plan, the gardens were transferred from a private possession of the crown to a national institution in 1840, with Sir William Hooker as the first director. About two hun-

dred and seventy acres are included, of which seventy are planted as a botanic garden and the remainder as an arboretum and public park. Besides the large number of well-planned conservatories, greenhouses, museums, and other buildings, it contains a number of structures which reflect somewhat of the varied history of the institution. The main palm house is three hundred and sixty-two feet in length, with a central dome seventy feet in height, and the temperate house has a total length of five hundred and eighty feet, covering an area of an acre and a half of ground. In addition, the garden contains fourteen smaller glass houses. The herbarium and library, which occupy the old palace of the King of Hanover, are probably the largest and most complete in the world. While the research work carried on in the gardens has been principally taxonomic, by the co-operation of the twenty-four gardens of which Kew is the organic head, much of value has been accomplished in the acclimatization of useful plants. There is also located in the garden the Jodrell Laboratory, in which some important results in physiology and

THE CUMBERLAND GATE, ROYAL GARDENS AT KEW, WITH GUARD ON DUTY.
Looking outward. After a photograph.

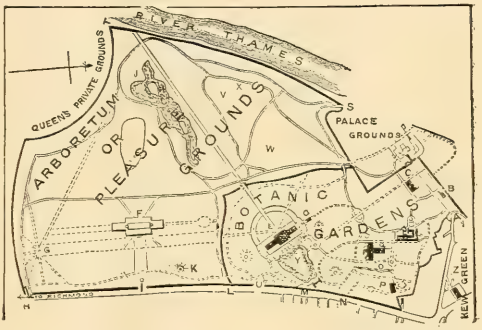
morphology have been reached. Its operations, however, are greatly constrained by lack of suitable endowment.

I quote the following explanatory paragraph from a guide to the grounds:

"It may be mentioned that Kew is not only a great educational establishment and pleasure resort, but also the recognized

center of the various botanic gardens throughout the empire. The part it has played in the introduction of the cinchona into India, and in fostering various other important industries, is well known. It may be described as the great botanical clearing house of the empire. To it a large number of plants are constantly being forwarded from all parts of the world to be named, for which purpose a staff of botanists is provided, and the collection of dried plants, or herbarium, as well as the large botanical library, is unrivaled throughout the world. In the same way the collection of cultivated plants and trees, both hardy and exotic, is the most perfect in existence."

The number of visitors to the gardens during the year amounts to one and a half million, according to newspaper reports. The gates, six in number, are open from noon until dusk. The administration and care of an establishment of this character near a great center of population require the closest organization and the most scrupulous attention to detail on the part of the executive. In this matter tradition as well as current testimony speaks of the rigid manner in which the numerous necessary regulations are enforced. The general plan of the grounds is shown in the adjoining map.



PLAN OF KEW GARDENS. Explanatory references: A, principal entrance from Kew Green; B, tropical house; C, timber Museum No. 3; D, water-lily house; E, palm house; F, temperate house; G, pagoda; H, Lion or Richmond Gate; I, "North" gallery; J, lake; K, flagstaff; L, Unicorn Gate (closed); M, Museum No. 1; N, Cumberland Gate; O, rockery; P, Museum No. 2; Q, new range; R, succulent house, greenhouse, and ferneries; S, Brentford Gate; T, Ilesworth Gate; U, Victoria Gate, for Kew Gardens Station; V, bamboo garden; W, azalea beds; X, Rhododendron Dell; Y, ornamental water; Z, Kew Church.

When organized chiefly for research the botanic garden differs in many essential features from the one described above. From this point of view, and with regard to advantages of geographical position and botanical possibilities, the garden at Buitenzorg in Java occupies a foremost position. Originally founded by the Government of Holland in 1817, for the purpose of testing the economic value of plants indigenous to the colonies of the East Indies, and for the distribution of seeds, plants, etc., after the customary manner of such institutions, it has widened its scope and developed its facilities until almost all branches of purely scientific and applied botany may be pursued to advantage within it.

The Buitenzorg Garden is situated within a few degrees of the equator, and by reason of the elevated areas included within its different divisions furnishes suitable conditions for the growth in the open air of plants native to latitudes as high as forty or fifty degrees. The luxuriance of the growth of plants in the lower tropical area may be imagined when it is stated that the average temperature is 85° Fahrenheit, and the yearly rainfall amounts to twelve feet. Of the eleven hundred acres available for the purposes of the garden, an area of about one hundred and seventy-three acres is devoted to experiments with cultivated plants, one hundred and forty-eight to the botanic garden proper, seventy-five to a mountain garden at an elevation of about seven thousand feet, and the remainder is comprised in a mountain forest. The laboratories are most excellently equipped for investigation in forestry, agricultural chemistry, and pharmacology, besides the main divisions of the pure science. In addition to a very complete library and herbarium, the administration has at its service a lithographic establishment for the preparation of illustrations for its publications. It would be difficult to overestimate the value of the results accomplished by the various divisions of this institution, or to predict its future performances. By reason of its facilities and resources it has become a Mecca for the botanists of the world.

The foundation of a botanic garden in the United States dates from that of John Bartram in Philadelphia in 1728, which is still preserved in a modified form. Botany has been given an important place in the college curriculum in America scarcely more than sixty years. In comparatively recent years a few gardens have come into existence, nearly all of which are still in a state of rapid development. During this period of flux they have been able only to afford facilities for general elementary instruction, and to make possible original work in the classification of native plants—a line of research which has been carried on more or less steadily since the earlier settlements were made on this side of the Atlantic. At the present time a few have begun to offer opportunities for research in the more important branches of botanical science. Among these may be mentioned the Missouri Botanical Garden at St. Louis, connected with the Washington University, the Botanical Garden and Arnold Arboretum of Harvard University, and the Botanic Garden of New York, now in process of formation and to be connected with Columbia University.

The Botanic Garden of Harvard University was established in 1805. It has an area of seven acres, on which are cultivated about seven thousand species of plants, principally native. For this reason it finds but one greenhouse necessary. The garden

contains the famous herbarium and library in which Asa Gray accomplished his work on the plants of North America. The main laboratories and museums are located in the university buildings.

ISLAND AND LAKE IN BOTANIC GARDEN, BUITENZORG, JAVA. Reproduced from "Der Botanische Garten 's Lands Plantentuin zu Buitenzorg, Java. Festschrift zur Feier seines 75-jährigen Bestehens," 1893.

Some very important work on the morphology of the cryptogams has been published from these laboratories. The Arnold Arboretum of Harvard University is organized entirely independent of the botanic garden. It includes an area of two hundred and fifty acres, of which one hundred and sixty are planted with trees and

shrubs. It is furnished with a museum, herbarium, and library, for the purpose of aiding study and research in forestry and dendrology. By an arrangement with the city of Boston the arboretum is thrown open to the inhabitants of that city as a public park. The arboretum has nearly completed a description of all the trees of North America north of Mexico in a series of magnificently illustrated quartos, entitled The Silva of North America.

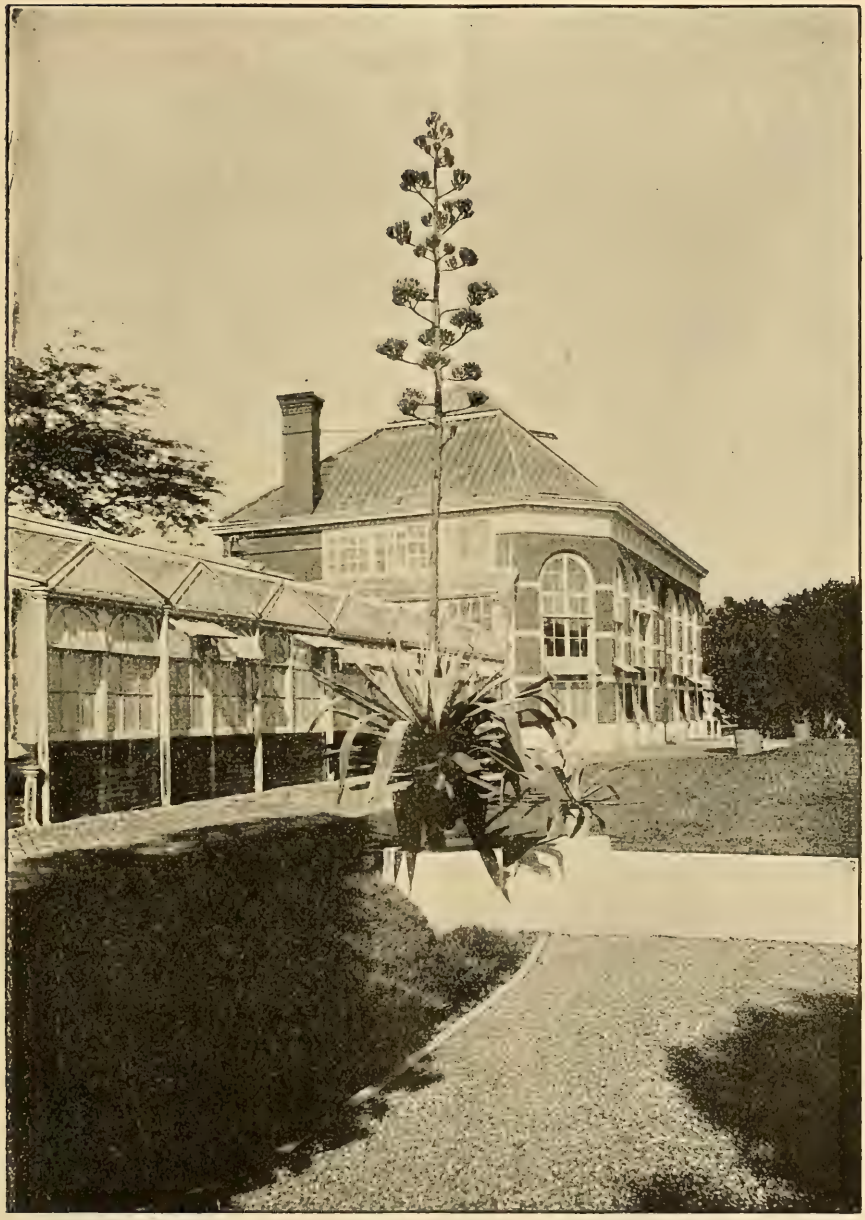
The foundation of the Missouri Botanic Garden at St. Louis is due to the munificence of Mr. Henry Shaw, who bequeathed for that purpose a tract of seven hundred and sixty acres of land and other property in and near St. Louis. The scope of this institution may be best illustrated by the following quotation from the will of its founder: "With a view to having for the use of the public a botanical garden, easily accessible, which should be forever kept up for the cultivation and propagation of plants, flowers, fruit and forest trees, and other productions of the vegetable kingdom, and a museum and library connected therewith, and devoted to the same and to the science of botany, horticulture, and allied objects." It is connected with the Washington University, which has a School of Botany also endowed by Mr. Shaw in 1885. The botanic garden occupies an area of forty-seven acres. The grounds are laid out in such a manner as to be highly attractive, and as many as thirty thousand people have passed the gates in a single day. Much important work in plant taxonomy has been accomplished in this institution, and the facilities for work may be set forth in the following official statement:

"The herbarium is supplemented by a large collection of woods, including veneer transparencies and slides for the microscope. The library, containing about eight thousand volumes and ten thousand pamphlets, includes most of the standard periodicals and proceedings of the learned bodies, a good collection of morphological and physiological works, nearly five hundred carefully selected botanical volumes published before the period of Linnæus, an unusually large number of monographs of groups of cryptogams and flowering plants, and the entire manuscript notes and sketches representing the painstaking work of Engelmann.

"The great variety of living plants represented in the garden and the large herbarium, including the collections of Bernhardi and Engelmann, render the garden facilities exceptionally good for research in systematic botany, in which direction the library also is exceptionally strong. The living collections and library also afford unusual opportunity for morphological, anatomical, and physiological studies, while the plant-house facilities for experimental work are steadily increasing. The E. Lewis Sturtevant Pre-Linnæan Library, in connection with the opportunity

afforded for the cultivation of vegetables and other useful plants, is favorable also for the study of cultivated plants and the modifications they have undergone."

The New York Botanic Garden is the most recent acquisition



VIEW OF MAIN GREENHOUSE IN THE MISSOURI BOTANIC GARDEN, WITH FLOWERING SPECIMENS OF AGAVE MEXICANA IN FOREGROUND. Reproduced by permission from the Fifth Annual Report of the Missouri Botanical Garden, 1894.

to the list of these institutions in America. Its establishment was authorized by the Legislature in 1891, but the enabling act being defective, no steps could be taken in its organization until 1894. To comply with the act of incorporation, a sum of two hundred and fifty thousand dollars was raised by private subscription, and then the Commissioners of Public Parks of New York City were authorized to set aside two hundred and fifty acres of Bronx Park, and the Board of Estimate and Apportionment was directed to issue bonds amounting to five hundred thousand dollars, to be used in the construction of the necessary buildings, greenhouses, museums, laboratories, etc.

The scope of this institution may be best illustrated by the following extract from the act of incorporation: "To be located in the city of New York for the purpose of establishing and maintaining a botanical garden and museum and arboretum therein, for the collection and culture of plants, flowers, shrubs, and trees, the advancement of botanical science and knowledge, and the prosecution of original research therein and in kindred subjects, for affording instruction in the same, for the prosecution and exhibition of ornamental and decorative horticulture and gardening, and for the entertainment, recreation, and instruction of the people." The site of the garden embraces an area of such wide diversities of soil and slope, marsh, meadow, shores, and granite ridges, that it will afford peculiarly fitting conditions for the growth of an extensive flora in the open air. As mentioned above, about one thousand species of plants, nearly all of which were native, were found on the inclosed area at the time of organization of the garden. Through a co-operative arrangement entered into with Columbia University, the herbarium of this institution, numbering over six hundred thousand specimens, as well as the library, will be deposited with the garden, and most of the research and graduate work of the university in botany will be carried on in the museum building. The plans of the museum building are such as to offer ample facilities for laboratories in all the divisions of the subject, while the glass houses promise to surpass anything in existence at the present time. The conditions of organization are such that a high efficiency for the entire equipment will be at once attained. The establishment of this garden marks an important step in the development of botany in America.

Perhaps the greatest opportunity for furthering botanical investigation that has existed since the beginning of the science now confronts the American universities in the proposal to establish a botanic garden and laboratory in the tropics. The real value of such an institution may be best understood when it is stated that botany in its present elementary condition, especially

with reference to the physiology and ecology of plants, is based chiefly on the results of investigations carried on in botanical gardens and laboratories situated in the northern hemisphere between the parallels of forty and fifty-five degrees. In the herbaria it has been possible to study normal specimens of prepared plants from the equator to the poles, and consequently the systematic relationships are much better known than any other characteristic. Morphology has shared these advantages to some extent.

In the study of the physiology, ecology, and other branches of the science in which living plants are necessary, attention has been necessarily confined to those indigenous to a zone fifteen degrees in width, extending across one small continent and half way across another, together with introduced species growing under more or less abnormal conditions in gardens and conservatories. As the science progresses it is becoming more and more apparent that many of the generalizations based upon investigations carried on under such circumstances are incapable of general application, and that before a permanent foundation for the science can be laid, research along all lines must be extended to include the most highly developed forms, in the primitive habitat of the plant kingdom, in the tropics. The principles of the relations of plants and their relations to the animal kingdom may only be attained by the study of undisturbed communities of plants in the natural groupings resultant from the struggle for existence. Here are to be found such rapidity of growth and metabolism that the adaptive possibilities of the organism reach their highest expression.

The centers of botanical activity in Europe are so far removed from a tropical flora that only occasionally does a transatlantic investigator find time and opportunity to extend his researches to include normal tropical forms. To do this he must visit Buitenzorg or some other garden nearly half way round the world.

The center of botanical activity in America has at its very doors a tropical region (in the West Indies), unsurpassed in every feature, which may be reached in four or five days from any important city in the country. The establishment of a laboratory and garden in any convenient locality would not only be of untold value in the general development of botanical science, but it would place within easy reach of the investigator or graduate student in American universities facilities unequaled by that of any other country.

The European botanist would also find a laboratory in the American tropics much more easily accessible than those of the antipodes. The foundation of such an institution would be of

direct benefit to the greater number of active botanists, and would go far toward making America the scene of the greatest development of the biology of one of the two great groups of living organisms.

II.—TÜBINGEN AND ITS BOTANISTS.

THE botanic garden connected with the old Würtemberg University at Tübingen is worthy of special notice, because of its history and its importance as a center of research in the biology of plants at the present time.

The university with which it is connected was endowed more than four hundred years ago by the reigning house of Würtemberg, and during the entire period of its existence it has enjoyed the exclusive patronage of the grand ducal and later the royal family, as it is the only higher institution of learning within the kingdom. Set as it is among a hardy and virile people, it has been the scene of many notable mental victories over tradition and superstition. It has always held a position in the forefront of human advancement, and its splendid achievements mark epochs in human thought. Here have originated great schools or methods of thought in the different branches of human knowledge. Bauer in philosophy and von Mohl in botany have each forwarded research in his respective line in a manner that can not be measured or easily estimated.

The subject of botany in this institution received its first attention from the side of medical science. With the introduction of the laboratory method of instruction, actual demonstrations of plants were used to supplement the lectures. To meet the need of material of living plants the garden was founded in due time, and it has at successive periods represented quite accurately the development and extension of botanical science,—a development to which the botanists of Tübingen have largely contributed. The subject of botany here has always been in the hands of workers of the first rank, who each in turn have materially advanced the frontiers of knowledge of the biology of plant life, for a period extending over three and a half centuries.

The first lectures on plants, dealing with their medical properties, were given at the university by Leonard Fuchs, from 1535 until his death in 1566, although it was not until a century later (1662) that the garden was founded. Fuchs occupied a prominent position in the history of ancient botany, since he made the first attempt to establish a system of terminology, and furthermore he was the first to base descriptions of species upon facts obtained from an actual examination of the plants themselves. In his *Historia Stirpium* about five hundred species are figured

and described, and the woodcuts in this quaint old herbal are of value even at this time. It is to be borne in mind, however, that Fuchs had formed no idea of the natural relationships of plants. The species given in the herbal are arranged in alphabetical order. It seems almost inconceivable at the present day, yet the descriptions of plants made by botanists in the period preceding Braunfels (1530) and Fuchs were not taken from nature, but were borrowed from still earlier writers, and supplemented by additions drawn purely from fancy and colored by the superstition of the time.

The establishment of the garden in 1662 was purely for the purpose of conserving medicinal plants, and only such species were cultivated as could be grown in the open air. The art of growing plants in artificially heated glass houses was not understood at that time. The garden occupied a plot of ground lying on the banks of the Neckar in what is now the heart of the city of Tübingen, where it remained until 1805, when it was removed to its present position.

SIMON SCHWENDENER, Professor of Botany and Director of the Botanic Garden, 1878. After a photograph by T. Barzuck, Berlin.

The lectures in botany in the university took on a new dignity when a separate chair was devoted to the subject by the appointment of Rudolph Jacob Camerarius as extraordinary professor and director of the botanic garden in 1688. He was afterward promoted and remained at the university until his death, in 1728. Camerarius made a most notable addition to botanical science by the actual experimental demonstration of the principal facts in the pollination of plants (1691 to 1694). Sachs says in his history of botany: "Camerarius had observed that a female mulberry tree once bore fruit, though no male tree (*amentaceis floribus*) was in the neighborhood, but that the berries contained only abortive and empty seeds, which he compared to the addled eggs of a bird. His attention was aroused, and he made his first experiment on another dicœcious plant (*Mercurialis annua*). He took, in the end of May, two female specimens of the wild plant (they were usually called male, but he knew them to be female) and set them in pots apart

from others. The plants throve, and the fruit was abundant and filled out, but when half ripe they began to dry up, and not one produced perfect seeds. His communication on this subject is dated December 28, 1691." The importance of his discovery was not recognized at the time, and his conclusions were accepted in a figurative sense only. Not until the end of the following century was his experimental evidence used as a basis for further researches by Kölreuter. Linnæus, to whom great credit is given by many writers for his share in the development of the theory of the sexuality of plants, ignored the facts disclosed by Camerarius, and arrived at identical conclusions in a purely deductive manner, arguing from the necessities of the case.

WILHELM PFEFFER, Professor of Botany and Director of the Botanic Institute, 1878–1887. After a photograph by W. Hornung, Tübingen.

After the demise of Camerarius he was succeeded by his son Alexander. Later the lectures on the subjects of botany and chemistry were given by one professor. After a short interregnum the subject was once more in the hands of a master spirit in the person of Joseph Gaertner, who was called to the chair of botany in 1760. Gaertner remained at Tübingen eight years, going to St. Petersburg to accept the chair of botany in 1768. He returned to Calwe in 1770, and published shortly afterward his *De Fructibus et Seminibus Plantarum*, which may be truly termed an epoch-making work. The study of fruits and seeds had languished for more than a century, and Gaertner came to it with a mind singularly free from prejudice. He was aware of the real value of fruits for the arrangement of plants in a natural system, but he did not attempt to found a system on such material alone. Having at hand a most extensive collection of plants from around the world, which he studied with a persistence that brought him nearly to blindness, his book is an inexhaustible mine of facts and a guide to the morphology of fruits and seeds. His collection of material and microscope are still preserved in the botanical museum.

The lectures in botany at the university were placed in the hands of Friedrich von Kielmeyer as professor of natural phi-

losophy in 1805. At this time the garden was removed to its present location, on the banks of the Ammer, in the northwestern part of the city, and shortly cold and warm houses for plants and a residence for the university gardener were erected. Kielmeyer was succeeded by Schubler in 1817, and he in turn by Hugo von Mohl in 1835.

It would be difficult to overestimate the value of the work accomplished by von Mohl during the thirty-seven years (1835 to 1872) in which he was professor of botany at Tübingen. This period does not include the entire time of his activity in this place, however. In 1826 the faculty of medicine offered a prize for an essay on the nature of tendrils and climbing plants, and a thesis by von Mohl, who was then a student, won the prize. This academic essay, written at the age of twenty-two, remained the clearest presentation of the subject until it was taken up by the elder Darwin in 1865. During the half century in which he was

Hermann Vöchting (sitting, facing front) and Group of Workers in Botanic Institute in Summer of 1896; Professor of Botany and Director of the Botanic Garden since 1887. After a photograph.

a leading figure in the botanical world, he used a purely inductive method of research, and by a long series of many-times repeated observations established manifold phenomena and facts which he welded into a coherent mass by a logic so relentless that he was incapable of being led astray into fanciful theories and dazzling speculations. Such a method enabled him to take a prominent part in the destruction of the chimerical teaching of the nature

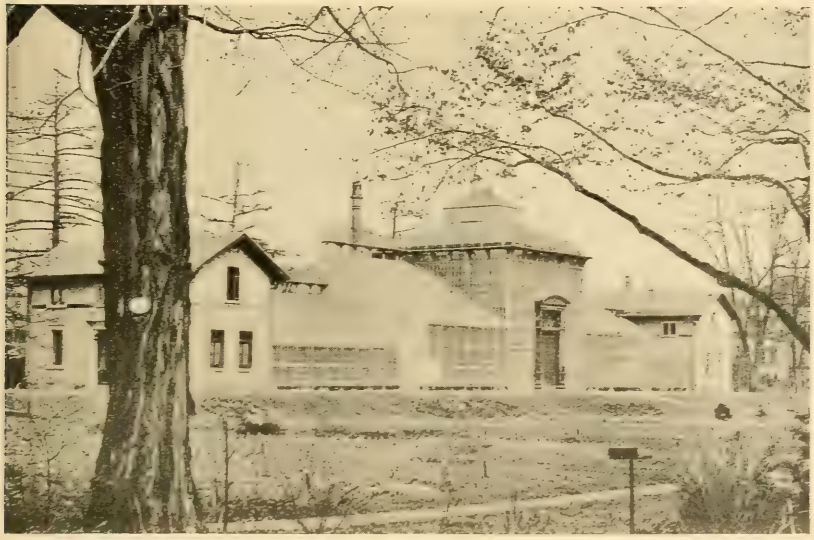
philosophy, especially in regard to the doctrine of the metamorphosis of plants. Furthermore, he succeeded in establishing the principles of anatomy so clearly that a rational system of morphology became possible for the first time. So important and basal were his demonstrations concerning the real nature of the primordial utricle that by many botanists he is said to have discovered protoplasm (1846). Von Mohl, with Schlechtendal, established the *Botanische Zeitung* in 1842. The list of his works includes ninety titles, embracing subjects in every department of the science. During his administration at Tübingen the garden was enlarged by three additions, to its present dimensions, occupying an irregular tract of land on both banks of the Ammer; important additions were made to the glass houses in the garden, and the institute building was erected in 1846. Perhaps no greater tribute can be paid to von Mohl's broad conception of the scope and needs of botany than the fact that this institute building erected fifty years ago, remains practically unaltered to the present day, and is still found fairly available for the purposes of modern investigation.

Upon the death of von Mohl, in 1872, he was succeeded by Hofmeister, who died after having held the post but five years. Hofmeister had perhaps accomplished his more important results before his stay at Tübingen. Like von Mohl, he used an inductive method of investigation, and he as well made enormous contributions to the material facts upon which many of our present generalizations in morphology rest. The results of the investigations published in his *Vergleichende Untersuchungen* in 1849 remain to-day superior to anything achieved in descriptive botany. To Hofmeister must be ascribed, among other important embryological results, the discovery of the alternation of generations in plants, and by the use of his phylogenetic mode of study the ideas concerning natural affinities of the groups of cryptogams and phanerogams underwent an almost total alteration. His establishment of the genetic relationship of these great subdivisions resulted in the overthrow of the prevailing belief in the constancy of species.

Prof. Simon Schwendener succeeded Hofmeister as director of the institute and garden in 1877. He, as well as his two successors, are still in the midst of active work, and it is by no means easy to forecast the final value of the results of their investigations upon the development of the subject. Schwendener has made very important contributions to the biology of lichens, phyllotaxis, besides a long series of contributions of the first rank in the domain of morphology and physiology. Among these his *Mechanische Princip in der Bau der Monocotylen* is of the greatest importance. Schwendener remained but a year at Tübingen, going

thence to the University of Berlin, where he vigorously continues his researches. In consequence of his short stay but little of his work was accomplished at Tübingen.

The direction of the institute and garden was assumed by Prof. Wilhelm Pfeffer in 1878, who remained in the place nine years. The splendid results accomplished by himself and students during that time are published in a set of two volumes entitled *Untersuchungen aus den botanische Institut zu Tübingen.* The work dealt with the principal problems of physiology in growth, turgescence, secretion, movements, respiration, and nutrition. In 1887 Pfeffer removed to Leipsic. Both before and after his stay



View of Palm Houses, Work Rooms, and Herbarium, in Autumn. After a photolithograph in "Die unter der Regierung seiner Majestät des Königs Karl an der Universität Tübingen errichteten und erweiterten Institut der naturwissenschaftlichen und der medizinischen Fakultät," 1889. By permission.

at Tübingen he made most important contributions to the science, especially with regard to the physical and chemical properties of plant tissues, notably in osmosis and turgidity, and also in the transformations of energy within the organism. His laboratories and lecture room are thronged with students from all over the world, many of whom are Americans.

The present director of the institute and garden, Prof. Hermann Vöchting, succeeded Pfeffer in 1887. Prof. Vöchting may be said to be to some extent a representative of the modern idealistic school with which Braun, his old teacher, was identified. His work, however, resembles that of the idealists only so far as to exhibit the immense value of comprehensive discussions of the results of careful inductive inquiry, not only in the establishment

of individual facts, but in the employment of these facts in their relations to the most general notions and their capabilities for the foundation of new and more comprehensive theories—a method of investigation productive of the highest results in all departments of biological science. One of the conclusions reached in this manner, which asserts the "polarity" of the plant cell, is at present beyond the general level of the subject. Polarity will doubtless be recognized as one of the most important physiological properties of protoplasm when the advance of the subject makes its appreciation possible. The researches of Vöchting have dealt prin-

THE BOTANIC INSTITUTE, VIEW FROM WILHELMSTRASSE.
After a photolithograph, by permission.

cipally with the physiology of movement and what might briefly be termed physiological morphology.

The garden is located in the northeastern part of Tübingen in western Würtemberg. It lies at an elevation of about one thousand feet, on the plateau encircled by the Schwarzwald, in latitude 48° 30′ north. Near it are hills covered with forests of pine, which rise two hundred and fifty to three hundred feet above it, while to the southward, twenty miles away, the Swabian Alps reach to a height of twenty-five hundred feet, in consequence of which the night temperature falls far below that of the day. A low winter temperature of −30° C., and a summer limit of 25° to 28° C., help to make a climate which resembles that of southern Michigan in many respects. The area inclosed amounts to about two and six tenths hectares of nearly level land on both sides of the banks of the Ammer, a small tributary to the Neckar. The grounds are planted in the system of Eichler, modified, however, to meet the

ecological and æsthetic requirements. A small portion is devoted to aquatic plants, a second to an arboretum, another to an experimental plot inclosed and accessible only to workers. In the entire garden the instinctive ability of the naturalist is shown in the selection of natural conditions for the specimens of the various flora represented, and the alpinum may be regarded as a triumph in the art of artificial culture.

The alpinum is laid out in the northwestern part of the garden on a rectangular plot of ground one hundred and ninety feet in length and nine feet in width, near a stone wall seven feet high and parallel to its length. On this plot are piled the rocks and soil necessary for the culture of plants, in an uneven ridge, which in one place is six feet in height. The materials used were principally the native stalactite limestone and gravelly soil and granite from the Black Forest, forty miles distant. The limestone is peculiarly suitable for the lower Alpine plants and lithophytes, furnishing, as it does, innumerable cavities for the reception of soil and secure foothold for plants which cling directly to the rock. It has been found that the species from the higher European Alps refused to grow on such rock, and hence the granite was procured for the section devoted to this group. The entire structure is in many respects an admirable imitation of an east-to-west mountain ridge. The northern side affords many shaded crevices, and more or less shade to the whole is given by a number of small trees near by.

The most difficult problems which have confronted the gardener in the construction and management of the alpinum have been those connected with the water supply. The water content of such rocky soils is of course extremely small and needs almost constant replenishment. In Nature this is done by water from the melting snows above. Here it has been accomplished by a system of branching pipes with many openings below and above the surface, and a flow is allowed during the greater part of the day. The drainage is carried away by cement conduits, and in one place forms an Alpine lake eight feet in length and five feet in width, which furnishes in its waters and on the overhanging cliffs admirable conditions for a very rich flora. Near the lake are growing several specimens of Edelweiss, which here becomes somewhat longer stemmed than on its native cliffs, or in the Alpine gardens where it is cultivated to satisfy the thirst of the tourist for mementoes of "hazardous" ascents.

Many of the Alpine plants are quite intolerant of lime salts and grow best on the granite rocks, but the water supply used here is taken directly from the city system and is very richly charged with these substances, and as a consequence the culture of some of the plants of the higher slopes is impos-

sible. This difficulty might only be overcome at some cost by a system of tanks for the storage of rain water, which would furnish exactly the natural conditions for a large number of species.

It is somewhat surprising to learn that in this area of about two thousand square feet more than twelve hundred species are successfully cultivated, almost all of which are perennials. In some places three or even four kinds are grown on a square foot of actual surface—a striking example of a form of intensive cultivation. It must not be supposed, however, that none but Alpine species are grown. A glance at the labels will show

Corner of Lecture Hall; View from Garden. After a photograph.

that many are at home far southward in the temperate zone. It is interesting to note that all of the North American species of *Cypripedium* are grown here successfully. As a matter of fact the alpinum offers a wider range of conditions than any other method of cultivation, and in some form similar to that described might offer suitable conditions of growth for species fairly representative of the flora of a region extending across twenty degrees of latitude.

The glass houses are of the usual form, and include a palm house two hundred feet in length, to which are attached workrooms and the herbarium building. The immediate supervision of the cultural department of the garden is in the hands of the head gardener, who is provided with a commodious dwelling and office building near the arboretum. He has under his direction a

force of men varying from eight to fifteen with the requirements of the season.

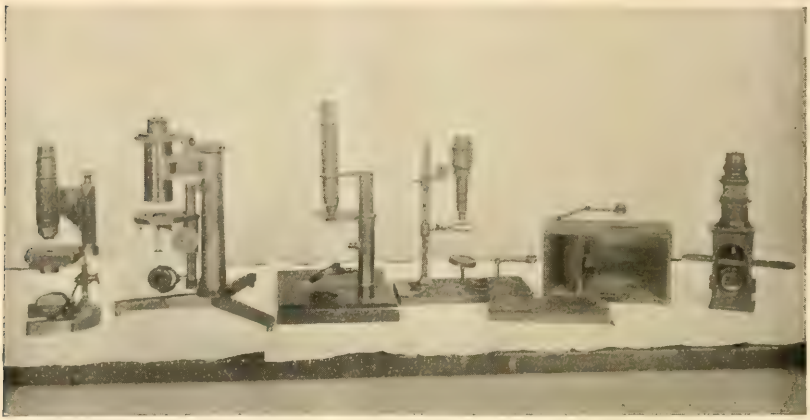
The institute is an oblong brick structure, one hundred and seventy feet in length by sixty-five in width, standing in the southeastern corner of the grounds. This building is two storied in part, the second story being devoted to the use of the director and his family. The first floor accommodates the director's offices, private laboratory, and experimental rooms, dark rooms, laboratories for physiology and morphology, the lecture room, and a museum containing the Gaertner collection.

The laboratories are supplied with a set of physiological apparatus embracing the standard forms, a large number of which were originally designed to facilitate researches undertaken here in the last twenty years. The museum contains the von Mohl collection of microscopes, which represents the development of this instrument from the time of Joseph Gaertner to that of Hofmeister, more than one hundred years. The Gaertner museum contains the carpological collections of Joseph Gaertner, on which his work *De Fructibus*, etc., was based, in the labeled bottles as prepared by him. For greater safety these bottles were inclosed in larger bottles and labeled by von Mohl, and the thoughtful observer looks forward to the time when a third casing of glass will be added to protect the prized handwriting of von Mohl. In this museum are also to be found the dried specimens of hybrids and seeds, drawings, manuscripts, and published works of Karl Friedrich Gaertner, and a large number of preparations for the microscope made by von Mohl and Hofmeister. The commodious lecture room is provided with all necessary appliances for successful demonstrations—charts, prepared specimens, wood and paper models, etc.

The investigator who comes here to undertake the solution of some problem in botany meets a body of congenial workers whose earnest enthusiasm is quickly contagious. He is furnished with ample space in well-lighted rooms and any necessary apparatus. If it is necessary to construct temporary apparatus to carry forward his experiments, a stock of material is at hand and he may have the intelligent assistance of the "Hausmeister," who has had a score of years of experience in such work in this institute. If the problem requires the application of delicate or complex machinery, he may call to his assistance Herr Eugen Albrecht—"Universitäts-mechaniker"—whose skill in designing effective apparatus for use in the physiology of plants and animals is known round the world. The library of the institute and that of the director contain a large number of works of the more prominent botanical authors, and a blank form properly filled will bring to his desk almost anything bearing upon his work from the

library of the university, containing two hundred thousand volumes, in an hour or two. Outside the laboratories lies a garden stocked with an immense variety of well-grown plants representing great diversities of form and habitat, and presenting suitable material for the solution of a number of the more important open questions in the subject. Stretching away on every hand is the rich flora of the limestone hills, crested by coniferous forests. The subalpine vegetation of the Swabian Alps may also be reached by an excursion of a few kilometres.

The forests, lying within half an hour's walk of the garden, embrace examples of the royal, communal, and private systems



GROUP OF MICROSCOPES FROM THE VON MOHL COLLECTION. The upright wooden stand on the right was used by Gaertner. The modern form on the left belonged to Hofmeister. The remaining stands were designed or used by von Mohl. After a photograph.

of management, and afford splendid opportunities for study in dendrology.

The most valuable part of the worker's experience, with such ample facilities at hand, however, is that which comes from the advice, encouragement, and suggestions of the director. Constantly engaged in the most laborious research for more than a quarter of a century, he has a vivid and sympathetic appreciation of the difficulties which beset the investigator, and his keen insight into the physiology of plant life leads him quickly to the solution of the problem in hand. His time and patience are unstintingly given to any who may have the slightest claim upon them, and the many times repeated assertion that the German professor gives a minor portion of his time only to his students is certainly ungrounded here. The writer is not acquainted with any American laboratory for botany in which the professor in charge devotes a greater proportion of his time to the student. In earlier times the Tübingen professors carried

this devotion to the interests of the student to such a degree that it amounted to a fault, and published their own researches under the names of their students. This generous, unselfish, and high-minded attitude is an inheritance in the Botanic Institute at Tübingen, and is characteristic of the people among whom it is situated.

In dead cells caffeine never produces proteosomes. If we treat *Spirogyra*, which is an excellent object for studying the behavior of the proteosomes, for one minute with a dilute solution of iodine in potassium iodide the globules may still be produced immediately afterwards but not after ten minutes. It can easily be shown that the substance has not passed to the outside by osmosis, since the liquid surrounding the treated algæ does not show any reaction with caffeine. Various tests proved that the proteosomes consist of protein matter, but in most cases there are impurities present, especially tannin, a fact which has misled Pfeffer and some of his students so far as to assume these proteosomes to be merely compounds of tannin with common albumin and with caffeine. It is evident that such compounds would not exist in two different modifications and would not change their entire behavior with the death of the cells as above described. Pfeffer's objections are untenable, as repeatedly demonstrated. He has, for example, assumed that on the death of the cells certain compounds leave the protoplasm and upon entering into the vacuole cause there a change of the proteosomes. But it is easy to convince one's self that proteosomes can also often be produced in the cytoplasm itself, especially in the case of *Spirogyra*. Since these proteosomes remain in the cytoplasm also unchanged so long as the cells are alive, the assertion of Pfeffer is groundless. He has also argued that the phenomenon in question, viz, the production of proteosomes, may be due to the neutralization of the acid cell sap, but we have shown that the cell sap of *Spirogyra* has no acid reaction* and nevertheless it yields frequently numerous proteosomes.†

It is to be regretted that many plant physiologists rely upon the declarations made by some 'authority' instead of forming their own opinion from an unbiased critical investigation. The history of science shows that erroneous conceptions are often sustained for a long time in scientific circles simply because a man of a certain influence has defended them. The recognition of the genuine respiration of green plants furnishes a good illustration to this remark. Liebig, by weight of his authority, wiped out this truth for 20 years from science.

OSCAR LOEW.

U. S. DEPARTMENT OF AGRICULTURE.

* Botanische Zeitung, 1884.

† A careful observer will not confound these easily changing proteosomes produced only in living cells (as Dr. Albert F. Woods has suggested) with other globular masses produced by hypochlorite of soda upon the protoplasm of dead cells. Such formations and their distinction from proteosomes were described by Woods in SCIENCE, April, 1899.

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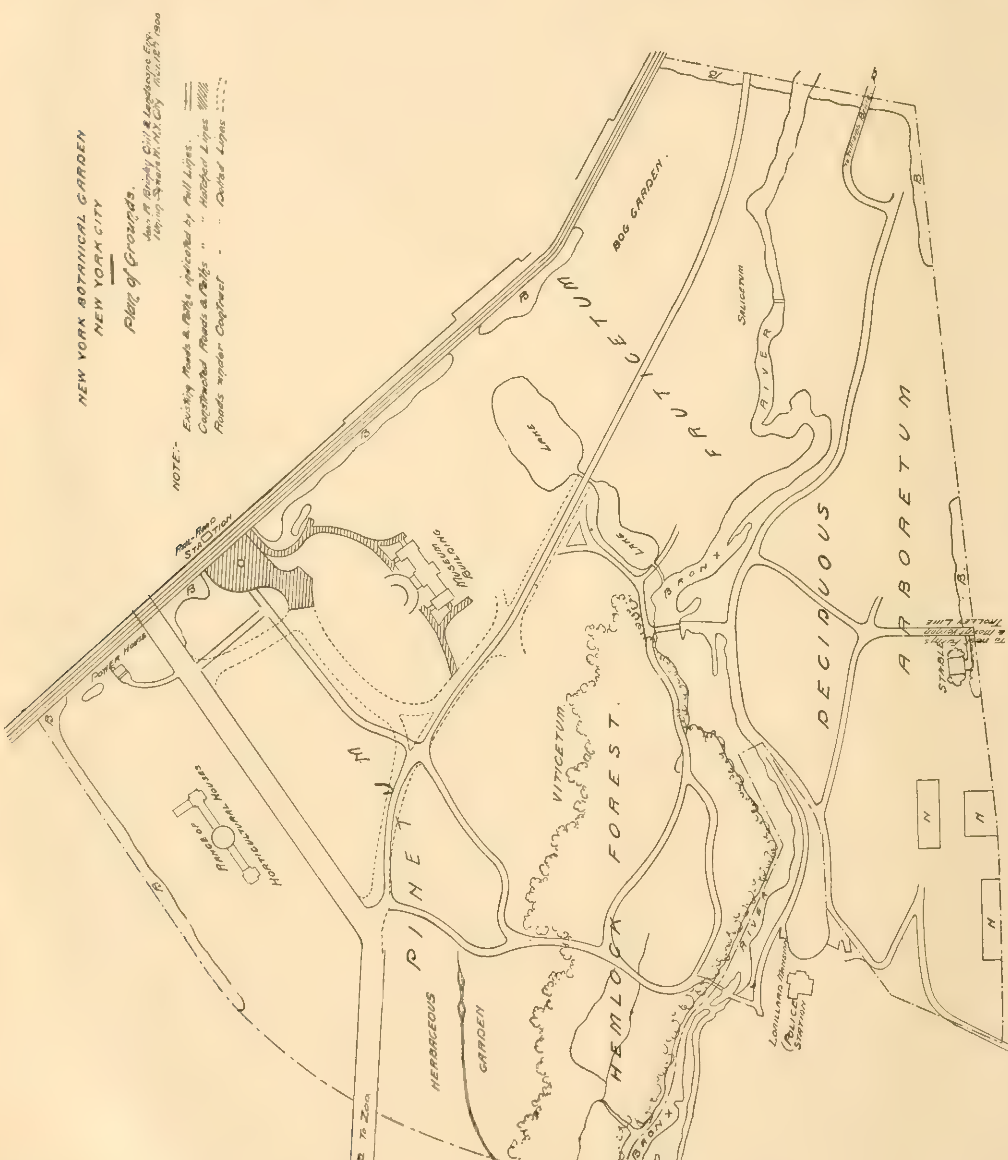
*THE NEW YORK BOTANICAL GARDEN.**

THE corporate body known as the New York Botanical Garden was created by an act of the legislature approved by the governor April 28, 1891, and amended March 7, 1894. This association was called into existence "for the purpose of establishing and maintaining a botanical garden and museum and arboretum therein, for the collection and culture of plants, flowers, shrubs and trees, the advancement of botanical science and knowledge, and the prosecution of original researches therein and in kindred subjects, for affording instruction in the same, for the prosecution and exhibition of ornamental and decorative horticulture and gardening, and for the entertainment, recreation and instruction of the people."

By the same act the Board of Commissioners of the Department of Public Parks were authorized to set aside two hundred and fifty acres of Bronx Park, and erect suitable museum and other buildings at a cost

* Written by the request of the Editor of SCIENCE. See also article on same subject by author in the *Popular Science Monthly* for June, 1900.

of not more than five hundred thousand dollars on condition that the corporation should raise the sum of two hundred and fifty thousand dollars within seven years. After the completion of the buildings these were to be handed over to the corporation which was to carry out the purposes for which it came into existence.



Map of New York Botanical Garden.

The subscription of the $250,000 required by the Act was completed, and the land was set aside in 1895.

The active work of organization of the

Garden was begun in 1896, and Dr. N. L. Britton was elected Director-in-chief in that year. The perfecting of the plans for the buildings, roads, driveways, walks and plantation occupied the greater part of the attention of the management during this year and the next. The actual erection of the most important of these structures, the museum building, was begun in the Spring of 1898, ground having been broken for it late in 1897, and it was handed over to the board of managers of the Garden in March, 1900. During this constructive period many additions were made to the staff, and a large amount of material suitable for the museums was accumulated, while much progress has been made in the building of driveways and the development of the plantations.

The area included within the Garden has been, and will be freely accessible to the public at all times, for the enjoyment of the beauties of the wild woodlands, and of the collections of living plants, but the completion of the museum and horticultural houses marks the beginning of the full activity of the institution and a brief description of the manner in which it discharges its chief functions may be of interest.

The collections of living and prepared plants in the plantations and museums are arranged to present information on the form, relationship, mode of life, habit, and general biological characters of the principal types of vegetation in such manner as to be capable of comprehension by persons unacquainted with the technical aspects of botany. A number of special groups of plants have been established in suitable places in the Garden. The trees are in the arboretum of the Bronx on the side and summit of a long ridge; unassorted and reserve material of all kinds is kept in the nurseries on the eastern slopes of the same ridge; the salicetum is established on the border of a marsh in the northern end of the Garden giving the willows and poplars the conditions under which they grow best. The fruticetum occupies an adjoining upland plain, affording space for the cultivation of a large number of shrubs, while the conifers are located on slopes to the westward of the hemlock forest. The viticetum is along the western edge of the forest, and the trellises of logs and timbers extending for a length of six hundred feet give suitable support to the vines. The herbaceous collection occupies an open glade to the westward of the forest and lies between two granite ridges. It is traversed through the middle by a small stream widened at places into lagoons for aquatic forms. About twenty-two hundred species are now in cultivation in this plantation. The wide border plantations which are established along the boundaries also offer opportunities for the growth of a great variety of trees, herbs and shrubs, and serve as screens and supplementary nurseries.

The horticultural houses, also erected by the city for the Garden and now essentially completed are located in the western part of the grounds at some distance from, and facing the museum. A palm house with a total height of dome of ninety feet is the central feature from which lower ranges extend on either side making a total length of front of five hundred and twelve feet.

The collections of living plants are arranged in the same system as the synoptic collection in the museum. Every plantation except the nurseries and boundary borders contains species of the same general habit, and the horticultural houses are used for the cultivation of forms which may not endure the outdoor climate of this locality. Not only will the plants from warmer zones be grown under glass, but when it is desired to develop native species out of their season they may be forced and brought to full development and bloom in the winter.

The museum is a fireproof building of brick, stone, and terra cotta, 308 by 110

feet, located in the western part of the grounds near the Bedford Park station of the Harlem division of the New York Central railroad. The building has a basement floor and three stories with a total floor area of nearly two acres, and window opening to half this amount, thus securing a good illumination, so highly desirable in a museum. A lecture theater occupies the basement floor of the western end, offering seating capacity for seven hundred hearers and furnished with all necessary appliances for the illustration of lectures. During the spring and autumn, courses of popular lectures are given on Saturday afternoons which have already drawn an attendance of from one hundred to five hundred. Adjoining the lecture hall are two large exhibition halls which are designed for horticultural shows and other temporary displays.

The first floor of the museum is devoted to the display of economic plants and their useful products. Glass fronted cases with movable and flying shelving are arranged in alcoves opening on the windows. Only about one-third of the case equipment of the building has as yet been set up. Dried specimens on herbarium sheets, conserved material in tubes, and jars, dry, and in formalin, and drawings, illustrate the method of preparation and appearance of the derivatives. It is of course utterly impossible

The Museum Building—New York Botanical Garden.

to demonstrate all the economic plants of the world or make even an approximately complete display within the space of a building, but the temporary installation now in place, represents many of the more important foods, drugs, timbers, woods, fibers, gums, waxes, resins, oils, sugars, starches, poisons, utensils, etc. The proper development of this collection requires a great amount of the most careful labor, and the curator has been fortunate in securing the co-operation of importers, producers, and manufacturers in the addition of exhibits.

The second floor contains a type exhibit of the vegetation of the globe arranged in families in the Engler and Prantl sequence. Specimens dry and in liquid preservatives, fruits, seeds, models, drawings and photographs are used to place the concept of the species before the observer. A set of hinged frames on standards contain the plants growing naturally within a hundred miles of New York City, and these are placed in their proper places in the series. Thus a case of the main series contains a representative of the family Violaceæ, and the frames near by display the local members of same family.

A number of microscopes of special design have been constructed for the purpose of displaying permanently the simpler and more minute organisms, or the structure of the higher forms.

The preparation of the material used in the exhibits is carried on in a number of rooms in the basement floor, and the members of the staff engaged in this work are assisted by a cabinet maker and printer.

The entire area of the Garden has been handled most sympathetically by those in charge of the architectural features of the Garden. The buildings were erected in the more open western part of the grounds, which offered the least valuable landscape features, and the surface around them has been improved by plantings. The natural beauties of the tract have been most zealously guarded from disturbances of all kinds. The attractive panorama of wild woodland and stream offered to the artist and lover of nature have been left absolutely untouched, but made more valuable by increased ease and safety of access. Thus to the general public, the Botanical Garden offers all the privileges enjoyed by them in the original park together with the interesting displays offered by the large special collections of interesting plants in the plantations and horticultural houses, as well as the exhibits in the museum. The increasingly large number of visitors attests the popularity of this feature of the institution.

Another class of constituents consists of the patrons, fellows, life members and annual members of the Garden, who now number over nine hundred. A person becomes an annual member on invitation of the Board of Managers and payment of ten dollars per year, and enjoys certain privileges among which are: tickets to all lectures given under the auspices of the Board of Managers either at the Garden or elsewhere, invitations to all exhibitions given under the auspices of the Board of Managers, a copy of all handbooks published by the Garden, a copy of all annual reports, copies of the monthly *Journal*, and an opportunity to buy some of the other publications of the institution at reduced prices.

One of the most important functions of the Garden consists in the advancement of the technical knowledge of botany and the furtherance of research in all subdivisions of the subject.

The collections in the plantations, horticultural houses and museum offers an excellent melange of material upon which investigations may be based, and the herbarium, library and laboratories are the direct means for the facilitation of such research work. The Garden, as an indepen-

dent institution, offers its facilities to advanced students or investigators from any part of the world who may secure registration in the proper manner. Persons thus registering at the Garden are entitled to the privileges of a student at Columbia University without payment of further fees in accordance with the terms of a contract in existence between the two institutions. The essential features of this agreement stripped of formal verbiage are as follows: student may become a candidate at Columbia or other institutions of university rank.

Twenty-two students have had the privileges of the Garden during the collegiate year now closing. Eight of these were registered as students at the Garden and fourteen from Columbia. Two of these have undergone the examination for the degree of doctor of philosophy, and three for master of arts in Columbia University.

Main Horticultural houses: view from the northwest. New York Botanical Garden.

the herbarium and botanical library of the University are deposited at the Garden, the graduate work of the University in botany is carried on at the Garden under the guidance of a member of the staff of the Garden or of the University according to the election of the student: students registered at the Garden may elect work with members of either staff, and are entitled to the privileges of a student in other lines in Columbia University.

It is to be noted that the Garden is not enabled to confer degrees, but the advanced

The great diversity of natural conditions offered by the area comprised in the Garden, includes the widest range of cultural conditions, and in connection with the horticultural houses gives ample facility for work with living material. These advantages have already been realized in the cultural tests of critical or little known species, and in physiological experimentation.

The range of investigations which may be carried on in any institution is limited by its collections of living and preserved specimens and the accomplishment of re-

searches upon this material depends directly upon the facilities offered by its herbaria, library, and laboratories, and the spirit in which these opportunities are administered.

The main herbarium, library, and laboratories of the New York Botanical Garden are chiefly located on the third floor of the Museum and their arrangement is illustrated by the diagram in figure 4.

The main herbarium occupies a room eighty-five by forty-seven feet in the east wing, which is illuminated by four large skylights in addition to the windows. The plants are arranged in two parallel series of cases occupying opposite sides of the room, with large oak tables in the middle and at the ends of the room.

The Columbia University herbarium occupies the western side of the room, and "it is one of the oldest, and in itself one of the largest in America, contains over 600,000 specimens. This herbarium was begun early in the century by Dr. John Torrey, and contains the material upon which his classic botanical writings, extending over half a century, were based. Upon his death, 1873, this collection came into the possession of Columbia College. On this as a foundation the present Columbia herbarium was built. Mr. John J. Crooke presented two valuable collections to Columbia; the one, that of Professor C. F. Meisner, of Basle, Switzerland, one of the world's leading botanists, the other that of the late Dr. A. W. Chapman, of Apalachicola, Florida, in which are contained the specimens upon which Dr. Chapman founded his 'Flora of the Southern United States.' A few years later the mosses, and many of the hepatics and lichens accumulated by Mr. C. F. Austin, came into the possession of Columbia, while the latest acquisition of great size and importance, secured through the kindness of friends of the university, was the famous collection of mosses brought together from all parts of the world by the late Dr. J. G. Jaeger, of Switzerland. To this ample nucleus Dr. Torrey's successor, Dr. N. L. Britton, while professor at Columbia, and his associates, added continually by securing collections from all parts of the globe, and by special collecting trips to various parts of North America.

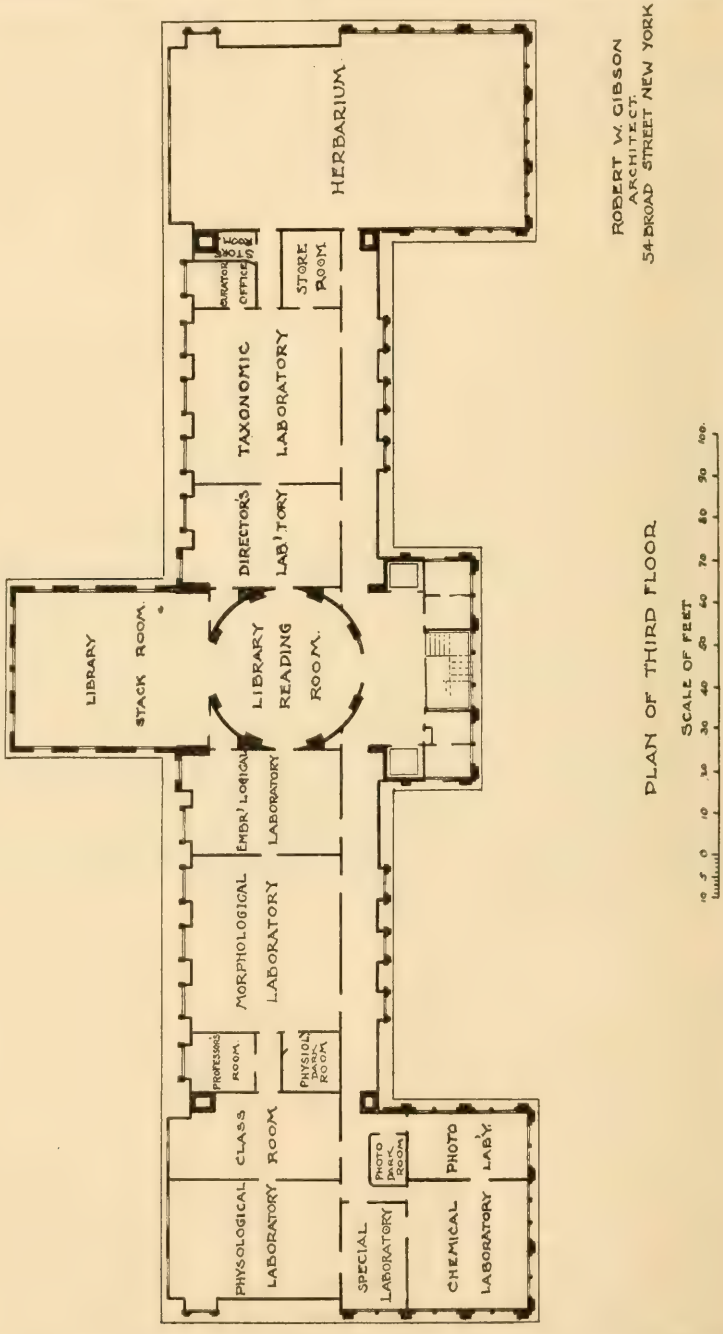
The most complete sets of specimens secured on two noteworthy South American journeys of exploration are here preserved; the one trip was that made by Dr. Rusby through the Andes of Bolivia, the other that of Mr. Morong in Paraguay and Chili."

The Garden has accumulated about 200,000 herbarium specimens since its organization. In this number is included the famous Ellis collection of fungi, including over a hundred thousand and forming one of the largest and most complete collections of fungi in the world, outranking any similar collection in America. Various private herbaria have been acquired by gift and purchase, among which are those of John J. Cooke, F. M. Hexamer, H. E. Hasse, P. A. Rydberg, Lewis R. Gibbes, Peter V. LeRoy, Harry Edwards, Anna M. Vail and Francis E. Lloyd. Accessions are being made at the rate of fifty to a hundred thousand specimens per year.

The main herbarium room is supplemented by two store rooms, and the office of the curator of the museums near it. In addition adequate preparation and storage rooms in the basement serve for the reception and handling of duplicate and unmounted material, as well as for the press upon which final labels are printed. Directly west of the herbarium suite is the taxonomic laboratory, which is especially adapted for systematic and anatomical investigations.

The laboratory of the Director-in-chief occupies a large room between the taxonomic laboratory and the library. The embryological laboratory occupies a cor-

responding position on the other side of the reading room, and opens into the main morward, and also receive indirect light from the hallway through numerous glass panels.



Plan of laboratories, libraries and herbarium, New York Botanical Garden.

phological laboratory. These laboratories are illuminated by windows facing north- The instrumental equipment of the laboratories comprises a number of microscope

stands suitable for investigators, from the most prominent makers, and a full complement of objectives, immersion and apochromatic. The outfit in question has been planned to meet the habits and prejudices of workers from any part of the country, and it has been found possible to duplicate the apparatus to which any student has become accustomed.

The construction for special furniture for the laboratories awaits the definition of the forms most suitable for the character of the work which may be undertaken here.

A most interesting comparison with the battery of modern high power optical apparatus on hand, is afforded by a collection of old microscopes given by Mr. Chas. F. Cox of the Board of Managers, which forms a special laboratory exhibit. This collection illustrates the development of the microscope during the last century and a half.

The physiological dark room opens from the morphological laboratory, and is fourteen feet square with double doors and independent ventilation, connecting directly with the outside air. It is heated indirectly by the walls of the contiguous rooms, and its position in the middle of the wing of the building together with its content of over thirty-five hundred cubic feet of air secure for it a very equable temperature. This room has been in constant use for six months including the period of tests of the heating system of the building and the total range of temperature has not exceeded four degrees centigrade, and at no time has a variation of two degrees been noted in a single week. The humidity varies from sixty to eighty per cent. in the work now in progress, and it has been found to offer much more suitable conditions for experimental work than any room used for a similar purpose which has come under the notice of the writer.

A corridor leads from the morphological laboratory to the class-room between the dark room and the office of the director of the laboratories (Professor's room, Fig. 4). The class-room is thirty-five by twenty feet, and one end is furnished with such accessories as to make it suitable for the weekly convention of workers from the laboratories. The other end serves for the private laboratory of the director of the laboratories and contains the departmental library.

The physiological laboratory is a skylighted room, thirty-five by thirty-two feet, occupying the corner of the building. It has a stone floor set in water-tight cement, a tank for aquatics, and tables for cultures. An ample heating surface is provided, and a special system of steam pipes around under the skylights secures ventilation, and acts as a preventive of dripping moisture. Ventilation of the ordinary type and that of the greenhouse are provided, while a set of shades may be used to cut off the direct rays of the sun. By such means a range of temperature similar to that of an intermediate greenhouse is secured. To this room are brought specimens from the plantations and greenhouses for experimental and observational purposes, and these are removed as soon as the work with them is finished.

A small chemical laboratory opens from the physiological laboratory, and leads into the large chemical laboratory occupying the corner of the wing. This room has not yet been provided with the special furniture and fittings necessary for chemical work. It has a large ventilating hood leading into a duct into which all the ventilating flues of the room empty. A ventilating fan driven by a powerful motor is capable of renewing the entire body of air in the room in a few minutes and thus preventing the escape of noxious gases into the contiguous laboratories.

The second corner of the wing is occupied by the photographic laboratory and

balance room, which is equipped with an outfit comprising a set of screens, cameras, and a selection of anastigmatic and planar lenses which provide for almost every contingency of indoor and outdoor work, including photomicrography and projection. The adjoining dark room opens directly into the hallway and contains the apparatus necessary for developing the printing.

The basement floor of the museum contains two rooms devoted to laboratory purposes. One is planned for the storage of chemicals and other supplies, for glassblowing and general preparation work. The second is a constant temperature room, thirty-four by twenty feet, furnished with double walls, doors and windows; this is designed to be separated into several smaller chambers in which different temperatures may be maintained. A series of thermographic tests of the temperature resulting from outside and inside causes are now in progress, from which the final fittings necessary for absolute control of the different temperatures may be determined.

The worker who comes to the herbarium or laboratories is supposed to have already demonstrated his ability to carry on independent research work, and after he has been provided with the necessities for the prosecution of the work he has only so much of advice and consultation with the member of the staff under whom he has elected work as to insure its successful prosecution. No facilities are given for elementary instruction. All the members of the staff and the workers in the laboratories meet once every week to listen to the presentation of results accomplished by one of their number, or by some visiting botanist. The opportunity for the discussion of newly found results has been found most stimulating to the persons concerned, and interesting to all attending.

The library consists of a large reading room or rotunda under the dome, of a stack or book room to the rear in the square central wing and two small store rooms for pamphlets and duplicates.

The stack room is admirably lighted by three west, four north and three east windows, and by a long central skylight. The reading room is lighted both from the windows in the dome and from the stack room, and is furnished with chairs and large oak tables.

The book stacks are forty in number, arranged along both sides of the book room. They are constructed by steel plate of one-tenth inch in thickness, are double-fronted, made in sections four feet long, two feet deep and six and a-half feet high, with solid ends and tops, but no fronts or doors, the lowest shelf being about three inches from the floor. They are painted a dark olive-green in japanned finish. Each stack is provided with five movable shelves with adjustable space or holes on the inside of the cases about one inch apart, through which small bolts are thrust to catch the shelves. For the folios there are four large metallic double-fronted cases, three feet high with a table top five by three and a half feet, in the center of the stack room. Each case has two sections on each front, one with three plain shelves and the other arranged with a system of roller shelves for the easier handling of the heavier folios.

In accordance with the agreement with Columbia University all the botanical books of this institution, amounting to about 5000, are deposited here. The Garden has acquired about 2000 volumes since its organization. The general character of the library may be known when it is stated that an invoice, February 1, 1900, showed 127 volumes of general dictionaries and non-botanical reference works, 100 volumes on general science, 200 volumes on geology and paleontology, 1733 volumes of periodicals and proceedings, 52 volumes of collective and historical works, 495 vol-

umes on morphology and physiology, 50 volumes on geographic distribution, 2105 volumes of floras and taxonomic monographs on the phanerogams, 900 volumes on cryptogams, 640 volumes on agriculture, 325 volumes on gardening, 200 volumes on forestry and 200 volumes on meteorology. The total number of volumes on the shelves was 7117. Since this count was made the additions raise the total to about 8000. Some care has been taken to exclude books and proceedings which have only an incidental interest to botany, with the idea that such additions decrease the actual working efficiency of the library and increase the labor necessary for its administration. The books are classified according to the Dewey system of indexing, and pamphlets and separates are not indexed or included in the count until bound up in volumes by subject.

The collective efficiency of the facilities described above is such that the institution bids fair to meet the expectations of all its different classes of constituents. The large number of specialists of the staff, together with those of other institutions who offer to guide research here, gives the student, who may come here to carry on investigations, the widest range of election of work. Among those offering to guide research in the Garden are: Professor L. M. Underwood, Dr. C. C. Curtis, Dr. M. A. Howe, Dr. N. L. Britton, Dr. D. T. MacDougal, Dr. P. A. Rydberg, Dr. G. V. Nash, Dr. J. K. Small, Professor F. E. Lloyd, Mrs. E. G. Britton, and Professor E. S. Burgess.

The personal interest and care shown by the members of the Board of Managers in the organization of the Garden has resulted in placing it on its present broad foundation, while the energetic administration of the business details by the Director-in-chief has brought the institution through the most critical part of its constructive period without departure from the original plans, without financial deficit, and with no undue loss of time.

The original guarantee fund has been preserved intact and increased by gifts and bequests to nearly $300,000, the income of which is available; a second source of income consists of the fees of the members, and a third source is the support received from the Department of Public Parks of the City of New York.

D. T. MACDOUGAL.

SCIENTIFIC BOOKS.

The Unknown. By CAMILLE FLAMMARION. Harper & Brothers. 1900. Pp. 488.

This volume consists of a plea for the existence of unknown or unrecognized psychical forces or manifestations, and an attempt to popularize this branch of investigation, by an astronomer who is known for similar contributions to other fields—some of them of a pronounced imaginative type. When one applies to the work the critical examination which science demands, the estimate of its value must be distinctly unfavorable. Its defects are many and serious; its merits do not go beyond those included in a laborious compilation of refractory material and a thorough and sincere interest. Its contents include two introductory chapters on the dangers of excessive incredulity as well as of a too ready credulity; a large collection of cases of communications made by the dying and regarded as evidence of telepathy; a similar collection of related cases of thought transmission and clairvoyance under other conditions; a consideration of dreams and of premonitions and of hallucinations, mainly again as indicative of abnormal psychic operations; and some scattered and weak attempts to interpret these phenomena on a telepathic and 'psychic force' hypothesis. The dominant tone of the book is one not uncommon in French writings of similar purpose, and one particularly unattractive to the Anglo-Saxon intellect; there is much protesting of the necessity of careful observation and of not accepting anything except on a sufficient evidence, and again of the limitations of human knowledge and of the readiness with which even

learned men make mistakes and form prejudices, and of the ultimate possibility of almost any theory and belief; there is much use of analogies without any discernment of the essential likeness or unlikeness upon which the value of all analogies rests; there is an attempt to write the matter up for and down to the public which when put into matter-of-fact and not too skillful English produces an unfortunate impression of self-assurance and an assumption on the part of the writer of an intense interest in his opinions on the part of the public.

Viewed as a contribution to a domain of knowledge most familiarly known as 'Psychical Research,' the work's fundamental faults are a lack of critical judgment in the estimation of evidence, and of an appreciation of the nature of the logical conditions which the study of these problems presents. In this respect it forms a marked contrast with the best of the English contributions to the same topics, notwithstanding an essential agreement of results. Although the motto of one of the chapters is 'Des faits! Pas de phrases,' the readiness of the author to accept as real fact the elaborated and often biased report of an unskilled witness, and to pay himself with words in his own use of the evidence, are lamentably conspicuous. A writer who can say of the reports of 4280 miscellaneous correspondents who reply to his request for cases of unusual 'psychic experiences'; "What struck me in all these narratives was the loyalty, good faith, frankness, and delicacy of the writers, who were careful to tell only what they knew and how they came to know it, without adding to or subtracting anything from the subject. Every one of them was the servant of truth," gives more evidence of his confidence in human nature than of his fitness to undertake such an investigation. A writer who can cite the persistence of sensations referred to amputated limbs, and the familiar principle of 'eccentric projection' that the sources of our sensations are referred outward to an external object, and the subjective character of color sensations, as psychological data suggestive of or corroborative of telepathy; who can transfer the physical principle of sympathetic vibration to imaginary brain vibrations and state that "All facts relating to the production and association of ideas can be explained by the occurrence of vibrations of the brain and of the nervous system which originates in the brain; this was demonstrated by David Hartley in the last century," gives further evidence of his incapacity for the task which he has elected to perform.

From beginning to the end of the volume there is no evidence that the author has considered or is familiar with the explanations of a non-telepathic nature which have been offered for some of the facts with which he deals. The fact that hypnotized subjects are quick to seize and act upon the unconscious wishes or suggestions of their hypnotizers is put down as evidence of telepathy without mention of other far more simple and more adequately demonstrated explanations; and the considerable evidence for regarding many 'veridical' presentiments and premonitions as illusions of memory is likewise ignored. Instead of a carefully developed logical argument, strengthened at every step by an examination of rival hypotheses and of the sources of error inherent in the evidence; instead of the critical analysis and differentiation of cases and a discernment of the prominent factors of community and divergence of the observations; we have only reiteration with increasing emphasis of the truth of the author's favorite hypothesis, and an endless compilation of stories that may be interesting and even significant but hardly justify the purpose to which they are applied. "Brains are centres of radiation." "But the actual FACT of the action of the soul at a distance is now demonstrated." "*The action of one human being upon another, from a distance, is a scientific fact; it is as certain as the existence of Paris, of Napoleon, of Oxygen, or of Sirius.*" "There are *mental transmissions, communications of thoughts, and psychic currents* between human souls." "PSYCHIC FORCE EXISTS. ITS NATURE IS YET UNKNOWN." "We may *see without eyes and hear without ears*, . . . by some interior sense, psychic and mental." "The soul by its interior vision, may see *not only what is passing at a great distance*, but it may also know in advance *what is to happen in the future*. The future exists potentially, determined by causes which bring